

Ontario. Environmental Appeal Board.
IN THE MATTER OF THE ONTARIO WATER RESOURCES ACT,
(R.S.O. 1980, C.361) AS AMENDED, AND IN THE MATTER OF
APPLICATIONS BY UNIROYAL CHEMICAL LTD.... 1992.



ENVIRONMENTAL APPEAL BOARD

IN THE MATTER OF the Ontario Water Resources Act, (R.S.O 1980, c.
361) as amended,

and IN THE MATTER OF applications by

Uniroyal Chemical Ltd.

dated January 12, 1990, January 19, 1990, and February 9, 1990 for a hearing before the Environmental Appeal Board with respect to an Emergency Direction dated December 30, 1989, and Notices/Directions dated January 18, 1990, January 26, 1990, and February 2, 1990 from the Director, Hamilton Regional Office, Ministry of the Environment, issued under sections 8, and 32(1) of the Ontario Water Resources Act as amended.

DECISION

February 4, 1992

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ENVIRONMENTAL APPEAL BOARD

IN THE MATTER OF the Ontario Water Resources Act, (R.S.O 1980, c. 361) as amended,

- and -

IN THE MATTER OF an application by Uniroyal Chemical Ltd. dated January 12, 1990 and amended January 19, 1990, for a hearing before the Environmental Appeal Board with respect to an Emergency Direction dated December 30, 1989 from the Director, Hamilton Regional Office, Ministry of the Environment, issued under s. 32(1) of the Ontario Water Resources Act as amended;

- and -

IN THE MATTER OF an application by Uniroyal Chemical Ltd. dated January 19, 1990, for a hearing before the Environmental Appeal Board with respect to a Notice dated January 18, 1990 from the Director, Hamilton Regional Office, Ministry of the Environment, issued under s. 8 of the Ontario Water Resources Act as amended;

- and -

IN THE MATTER OF an application by Uniroyal Chemical Ltd. dated February 9, 1990 for a hearing before the Environmental Appeal Board with respect to the Notice dated February 2, 1990 from the Director, Hamilton Regional Office, Ministry of the Environment, issued under the Ontario Water Resources Act;

- and -

IN THE MATTER OF a Hearing held:

January 24, 1990	in the Council Chambers, City Hall, City of Kitchener
February 28, 1990	in the Crystal Ballroom, Walper Terrace Hotel, Kitchener
March 9, 23, 24, 28 & 30, 1990	in the Crystal Ballroom, Walper Terrace Hotel, Kitchener
May 2, 1990	in Room P2027, Frank C. Peters Building, Wilfred Laurier University, Waterloo
May 3, 4 & 7, 1990	in Room C23, Frank C. Peters Building, Wilfred Laurier University, Waterloo
June 6, 7, 15, 18, 25, 1990	in the Auditorium, St. James Lutheran Church, Elmira
July 16, 17, 18 & 19, 1990	in the Auditorium, St. James Lutheran Church, Elmira
August 13, 16, 17, 1990	in the Auditorium, St. James Lutheran Church, Elmira
September 8, 18, 25, 1990	in the Auditorium, St. James Lutheran Church, Elmira
October 23, 30, 1990	in the Auditorium, St. James Lutheran Church, Elmira
November 13, 1990	in the Algonquin Room, Macdonald Block, 900 Bay Street, Toronto
November 16, 1990	in the Humber Room, Macdonald Block, 900 Bay Street, Toronto
December 4, 1990	in the Buckingham Room, the Westbury Hotel, 475 Yonge Street, Toronto
December 6, 1990	in Hearing Room #2, Ontario Highway Transport Board, 151 Bloor Street West, Toronto

BEFORE:

Knox M. Henry, Panel Chair
Prof. Barry J. Adams, Member
Dr. Mary C. Schwass, Member

GLOSSARY:

The Environmental Appeal Board respectfully refers readers of this Decision to the Glossary attached to this Decision as Appendix J which lists the explanation of names, technical terms and annotations used for purposes of brevity throughout this document.

APPEARANCES:

Mr. W. A. D. Millar	counsel, on behalf of Uniroyal Chemical Ltd.,
Mr. J. M. Buhlman	
Mr. J. G. Cowan	
Mr. S. D. Berger	counsel, on behalf of the Director, Hamilton Regional
Ms S. Ficek	Office, Ministry of the Environment
Mr. C. McNamee	
Mr. H. Poch	counsel, on behalf of the Regional Municipality of
Ms C. Albert	Waterloo
Mr. E. Moore	
Mr. R. Power	
Mr. T. C. Flannery	counsel, on behalf of Assuring Protection of Tomorrow's
	Environment
Mr. T. R. Lederer	counsel, on behalf of Sundor Canada Inc.
Mr. D. T. Hamilton	
Mr. S. Garrod	counsel, on behalf of the Township of Woolwich

WITNESSES:ON BEHALF OF:TESTIMONY RELATED TO:

Mr. Stefan E. Salbach	MoE	Acting Director, MoE; History, Reasons for Actions, Methods
Dr. Richard T. Burnett	MoE	Statistical Analysis of Toxicological Data
Dr. Vincent Y. Taguchi	MoE	NDMA Chemical Analysis
Ms Ann Vajdic	MoE	Drinking Water Quality Criteria
Mr. Bryon F. DeFrance	MoE	Toxicology of NDMA
Mr. Mark W. Ethier	MoE	STP Operations and Sampling
Dr. Otto Meresz	MoE	NDMA Chemical Analysis
Ms Mary E. (Bette) Meek	MoE	Drinking Water Quality Criteria and NDMA Toxicology
Mr. Donald E. King	MoE	Chemical Analysis, Quality Assurance/Quality Control
Mr. Richard P. Vickers	MoE	Water Resources Assessment
Mr. Gerald A. Thompson	RMoW	Municipal Water and Wastewater Facilities in the RMoW
Mr. Ralph W. Luhowy	RMoW	Water and Wastewater Facility Operations
Dr. Roisin McCallum	RMoW	Public Health
Dr. Ronald J. Sax	RMoW	Public Health
Dr. Earl E. Shannon	RMoW	Sampling and Analysis Protocol
Dr. Thomas E. Pollock	RMoW	NDMA and Water Treatment
Mr. George Zukovs	RMoW	Water Resources Assessment
Dr. Ronald W. Brecher	RMoW	NDMA Toxicology
Dr. George Lunn	APTE	NDMA Chemistry

Dr. Donald L. McLeish	APTE	Statistical Analysis of Toxicological Data
Dr. William Lijinsky	APTE	NDMA Chemical Analysis and Toxicity
Mr. Walter K. Ruck	Uniroyal	General Manager, Uniroyal Chemical, Ltd., Elmira, Ont.
Mr. Timothy R. Boose	Uniroyal	Uniroyal Treatment Operations
Dr. Earle R. Nestmann	Uniroyal	NDMA Toxicology
Mr. Ronald Frehner	Uniroyal	NDMA Wastewater Treatment
Dr. Edward A. McBean	Uniroyal	Water Resources Assessment
Dr. Anthony S. Riggs	Uniroyal	Analytical Chemistry
Dr. Mark A. Thompson	Uniroyal	Toxicological Risk Assessment
Dr. David M. Borth	Uniroyal	Statistical Analysis and Quality Control
Mr. Bruce C. Clegg	Uniroyal	Chemical Analysis, Quality Assurance/Quality Control

PUBLIC STATEMENTS BY:

Mrs. Sandra B. Bray

Mr. Alexander D. McKinnon

Mrs. Sheila A. Prociw

Mrs. Barbara E. Smith

Mr. Randy J.A. Smith

Dr. Darrol Bryant

Ms Mary Ragula

BACKGROUND:

This is an appeal by Uniroyal Chemical Ltd. (hereafter referred to as Uniroyal) against an Emergency Direction (hereafter referred to as the Order), and two subsequent Notices from the Director (hereafter referred to as the Director), Hamilton Regional Office, Ministry of the Environment (hereafter referred to as the MoE). These actions of the Director were designed to have the effect of forcing Uniroyal to discontinue the use of any chemicals that may cause the production of the chemical compound N-nitrosodimethylamine (hereafter referred to as NDMA) and of ceasing the discharge of NDMA as a part of Uniroyal's wastewater (effluent) to the Elmira sewage treatment plant.

Uniroyal is a manufacturer of various chemical products used primarily in the agricultural, rubber and plastics industries. Uniroyal is located in the town of Elmira, a rural community situated in gently rolling farm land about 100 kilometres northwest of Toronto. The firm has existed at the same site straddling the Canagagigue Creek since its founding in 1942 as a producer of chemicals for the manufacture of munitions used in World War II.

The wastewater resulting from the various chemical manufacturing processes, along with the rainwater collected from the roofs of the many buildings on site, is collected and processed through Uniroyal's wastewater treatment facilities. The treated wastewater flows through a dedicated sewer to the Elmira sewage treatment plant (hereafter referred to as the STP) which is located on property adjoining the southern boundary of Uniroyal's property. The Uniroyal wastewater effluent is mixed within the STP with sewage influent from the town of Elmira, treated, then released to the Canagagigue Creek - a tributary of the Grand River. The Grand River flows in a southerly direction through the 'twin' cities of Waterloo and Kitchener and eventually discharges into Lake Erie.

The Elmira STP was built in 1963 as a joint project between the Regional Municipality of Waterloo (hereafter referred to as the RMoW or the Region) and Uniroyal to provide treatment of the town's sewage and industrial waste from Uniroyal which are in the approximate ratio of 2:1. Uniroyal pays about one-third of the annual operating costs of the STP. One-third of the capital cost required to expand the STP in 1984 was provided by Uniroyal. The STP is owned by the RMoW and operated on its behalf by the Ontario Ministry of the Environment.

The town of Elmira, the cities of Waterloo and Kitchener and a large portion of the surrounding area, including many villages and towns, are incorporated by provincial legislation as the Regional Municipality of Waterloo. The RMoW bears responsibility for providing municipal water supplies where it deems such facilities are required. The town of Elmira has a municipal water system - operated by the RMoW - which uses several local-area wells as its source of water. Several wells are clustered in the north section of the town and referred to as the north well field. The balance of the town's water supply comes from the south well field which includes the two wells E-7 and E-9 and is located in the southern part of the town.

In the past, this latter well field also supplied water to the community of St. Jacobs, a village located a few kilometres south of Elmira.

The Drinking Water Section, Water Resources Branch, MoE, administers the MoE policy of periodically checking each municipal well in Ontario for the presence of any chemicals in the water that might prove harmful to the public. The first testing under this program of the wells in Elmira was undertaken after the program began in 1981. During the second test in 1988, the MoE analysed water samples from wells west and south of Uniroyal, and south of the Elmira STP, with their gas chromatography/mass spectrometry (GC/MS) testing equipment. The results of these tests indicated the presence of low levels of NDMA. The MoE interpreted these results as not indicating any need for concern about the municipal water supply in Elmira.

On September 19, 1989, samples were taken of the water from Elmira's north and south well fields. These samples were subjected to the broad spectrum analysis of the MoE's GC/MS testing equipment. The testing process, at that time, required about 4 to 5 weeks duration in the laboratory. On November 9, 1989, when the analysis of the samples was completed, the results - indicating the presence of NDMA in well E-9 in the south well field, at a concentration of 3 parts per billion (ppb or 3 µg/L) in the raw water and 4 µg/L in the treated water - were communicated to the MoE offices in Hamilton and Cambridge.

At that time there were no Federal or Provincial Drinking Water Guidelines setting out limits for the amount of NDMA to be allowed in drinking water. A check with the authorities at the United States Environmental Protection Agency (hereafter referred to as the U.S. EPA) provided the information that the U.S. EPA considered nitrosamines - the family of chemical compounds which includes NDMA - as potential human carcinogens - that is, they can be a cause of human cancer. Consequently, the U.S. EPA had set an ambient water quality guideline for NDMA of 0.014 µg/L (parts per billion). On November 10, 1989, the MoE set an Interim Drinking Water Quality criterion for NDMA of 0.014 parts per billion (ppb or µg/L).

On November 10, 1989, the MoE notified the Medical Officer of Health for the Regional Municipality of Waterloo of the test results indicating the presence of NDMA in well E-9. That afternoon the Region shut down well E-9. The next day well E-7 which is adjacent to well E-9 was shut down.

An investigation was immediately commenced by the MoE to determine the source of the NDMA found in the well water. Concurrently, repeated extensive sampling was undertaken of the water in all the municipal wells as well as in many private wells.

The investigation to determine the source, or sources, of the NDMA in wells E-7 and E-9 encompassed a wide area including the possibility that the NDMA might be emanating from the lubricants used in the pumps in the wells. Concern about this particular source was proven to be unfounded.

Uniroyal, which had been contacted by the MoE at the beginning of the investigation, co-operated with the MoE in its investigations. Mr. Robert Hillier, a hydrogeologist with the MoE, met with Uniroyal officials on December 8, 1989 and developed a sampling program to assist in identifying any potential sources of NDMA at the Uniroyal site.

On December 16, 1989, the MoE's investigative program revealed that samples taken on November 30, 1989 from the effluent from the Uniroyal plant to the Elmira STP had very high levels - in the order of 2000 ppb - of NDMA. On December 16, 1989 Uniroyal was verbally advised by the MoE that it must cease all discharges of NDMA to the STP. Extensive discussion took place over the next few days between the MoE and Uniroyal and on December 20, 1989, Uniroyal submitted a detailed work program to identify all sources of NDMA and dimethylamine (DMA), a chemical building block of NDMA, in its processes and to eliminate all discharges of NDMA to the STP.

On December 29, 1989, Uniroyal was advised of the terms of an Emergency Direction being prepared by the MoE. The formal Emergency Direction was served on Uniroyal on December 30, 1989 (Appendix D). As a result of further tests on the effluent from Uniroyal to the STP showing fluctuating high levels of NDMA, and as a result of tests on water downstream from Uniroyal and the Elmira STP, in the Canagagigue Creek and the Grand River, the Director issued two Notices to Uniroyal on January 18, 1990 (Appendix E) and February 2, 1990 (Appendix G), respectively. A letter to Uniroyal dated January 26, 1990, contained the Director's approval of the abatement plan to be undertaken by Uniroyal (Appendix F).

Uniroyal appealed portions of the Emergency Direction dated December 30, 1989, the two Notices of January 18 and February 2, 1990, and the letter of January 26, 1990 of the Director, to the Environmental Appeal Board.

ISSUES:

In its Consolidated Grounds of Appeal filed with the Board (exhibit 11), Uniroyal stated:

" I. GENERAL GROUNDS

1. The discharge requirements set out in paragraphs 4 and 8 of the said Emergency Direction are arbitrary, unreasonable and unjustifiable on an environmental or technological basis.
2. Having regard to the levels of NDMA in common edible foods and beverages, the permissible levels of NDMA specified in paragraphs 4 and 8 are unduly low.

3. The Ministry of the Environment's analytical testing methods and protocols are not proper.
4. The Ministry of the Environment's sampling methods and protocols are not proper.
5. The various results obtained by the Ministry of the Environment upon which Mr. Salbach based his Notices/Orders to cease discharging to the Elmira Municipal Sewage Treatment Plant are not accurate.
6. Uniroyal is unable to comply with the Direction in Part III, paragraph 11 that it report the result of all analyses to the Director within 72 hours of the time a sample is taken by reason of the number of samples and the fact that the laboratories equipped to perform the required analyses are unable to provide Uniroyal with the results of their analyses within the required period of time.
7. The time necessary to complete the analyses required by the Emergency Order is extended by the need to establish a Quality Assurance/Quality Control Protocol for the sampling and analyses for each sample location with respect to NDMA at the low detection levels required and the difficulty in analyzing relatively dirty waste water process samples from the Plant which require special sample preparation.
8. With respect to Part III, paragraph 3, Uniroyal seeks a variation of the location of the sample from the "inlet to the Uniroyal Chemical aeration tank in Elmira" to the "outlet from the Uniroyal Chemical aeration tank in Elmira" for the following reasons:
 - (a) a sample from the "outlet" from the aeration tank is less subject to fluctuations from various process conditions than a sample from the "inlet";
 - (b) such a sample would be an easier sample to analyze because it would be cleaner than a sample taken from the "inlet";
 - (c) such a sample would be a more representative sample of the Plant effluent than a sample taken at the "inlet".
9. The level of discharge of N-nitrosodimethylamine ("NDMA") by Uniroyal into the Elmira Sewage Treatment Plant and the level of discharge of NDMA from the Elmira Sewage Treatment Plant:
 - (i) poses no danger to the health or safety of any person;
 - (ii) does not impair nor create an immediate risk of impairment of any waters;

(iii) has not caused injury or damage or the immediate risk of injury or damage to any property, or to any plant or animal life.

10. The impact of the Emergency Direction and Notices/Orders dated January 18, 1990, January 26, 1990, and February 2, 1990, is totally disproportional to the problem or perceived problem which the Direction seeks for [sic] remedy.

11. The effect of the Emergency Direction and the Notices/Orders dated January 18, 1990, January 26, 1990, and February 2, 1990, will be to close Uniroyal's Elmira Plant without a hearing.

12. Uniroyal has worked with the Ministry of the Environment and continues to work with the Ministry of the Environment to remedy the problem and perceived problem.

II JURISDICTIONAL GROUNDS:

13. The Director has no jurisdiction to make the said Emergency Direction dated December 30, 1989, as no situation of emergency existed or exists and has no jurisdiction to issue the Notices/Orders dated January 18, 1990, January 26, 1990, and February 2, 1990.

14. The Director has no jurisdiction to make the Emergency Direction dated December 30, 1989 under s.32(1) of the Ontario Water Resources Act and has no jurisdiction to issue the Notices/Orders dated January 18, 1990, January 26, 1990 and February 2, 1990.

15. While s.17(1) of the Ontario Water Resources Act permits the Director to prohibit or regulate the discharge of sewage into a well, lake, river, pond, spring, stream, reservoir, artificial watercourse, intermittent watercourse, ground water or other water or watercourse, the Emergency Direction in question and the Notices/Orders dated January 18, 1990, January 26, 1990, and February 2, 1990, purports to prohibit discharge into a sewage treatment plant, an action for which he has no authority under the Act.

16. The Director has purported to set standards for the content of sewage entering the the Elmira Sewage Treatment Plant and for industrial waste effluents when the non-delegable right to make regulations in this regard is vested pursuant to s.44(1)(f) and (h) of the Ontario Water Resources Act in the Lieutenant Governor in Council; "

CHRONOLOGY OF EVENTS:

The following chronology of events is not exhaustive. It is presented to provide a brief overview of some of the major occurrences that took place in the span of a few very busy months.

- In November, 1989, N-nitrosodimethylamine (NDMA) was discovered in the Elmira wells E7 and E9. The Ministry of the Environment immediately commenced an investigative search to locate the source of the NDMA.
- December 8, 1989, Mr. R. Hillier, MoE, instituted a sampling program at and near the Uniroyal site. The analytical results of the sampling program were reported a few days later with the recommendation that: "the focus of any further study should be on the Uniroyal property. This should include a modest drilling program to install monitoring wells adjacent the Uniroyal property between existing monitoring wells 19d and 18d." (exhibit 20, p.54)
- After December 8, 1989 and before December 20, 1989, (the exact date was not provided in evidence), Mr. D. Ireland, MoE, and Mr. R. F. Staples, Uniroyal, discussed the situation by telephone.
- On December 20, 1989, Mr. Staples responded to the telephone conversation with Mr. D. Ireland by means of a letter in which he discussed the "identification of sources of NDMA at Uniroyal's Elmira Plant" and set out a 12-point program which he felt would identify all sources of dimethylamine and NDMA in the Elmira plant and show how formation of NDMA would be eliminated in the plant wastewater effluent. (exhibit 1, p.1)
- On December 21, 1989, Mr. S. Salbach discussed events with Mr. W. Ruck, General Manager, Uniroyal, in a telephone conversation and was advised that Uniroyal had been vigorously investigating any potential sources of NDMA in their processes. Mr. Ruck stated that Uniroyal had suspected their use of DMA may have been the source of NDMA and confirmed they had ceased using DMA. Mr. Salbach was also advised that Uniroyal would be shutting down for the 'holiday season'. Mr. Salbach interpreted Uniroyal's 'holiday season' to mean the period from December 24, 1989 through January 2, 1990 rather than from December 24 through December 27, 1989.
- On December 28, 1989, as a result of a scheduled meeting held that same day between Uniroyal and MoE staff to discuss methods of remediation of NDMA contamination of wastewater, Mr. Salbach learned that Uniroyal had restarted operations. Mr. Salbach immediately began legal actions to prepare an order to 'contain the problem'.
- On December 29, 1989, Mr. W. Ruck, General Manager of Uniroyal confirmed in writing the points he discussed in a telephone conversation he had that morning with Mr. Salbach, which outlined:

- the taking of samples of effluent from Flexzone and Delac units;
 - that Synton PAO effluent is contained in drums for analysis and would not be discharged to the Treatment Plant until this analysis has been completed;
 - that Uniroyal would not start any additional operations until the analytical results had been received from those currently operating, and any future start-ups would be conducted in a prescribed sequence; and
 - that it was anticipated that the next unit start-up would be on January 5, 1990. (exhibit 20, p.61)
- In the afternoon of December 29, 1989, the terms of the proposed Emergency Direction were communicated to Uniroyal in a telephone conversation among Mr. Salbach, Mr. Berger and Mr. Ruck.
 - On December 30, 1989, an Emergency Direction (the Order) was issued by Mr. S. E. Salbach, Acting Director, Hamilton Regional Office, MoE, (see Appendix D attached hereto) which specified 15 terms under the Order including: "discontinue immediately any discharge into the Municipal Sewage Treatment plant, in the event that NDMA is detected in the Sewage Treatment Plant effluent at a level greater than 0.5 µg/L and any detectable quantity of NDMA is present in Uniroyal sewage." (exhibit 2D, p.4).
 - On January 3, 1990, Mr. Ruck forwarded Uniroyal's proposed start-up sequence to the MoE. (exhibit 20, p.68)
 - On January 4, 1990, Mr. Salbach refused to allow the start-up, giving as his reason the grounds that "the detection levels for the three samples vary from 4 to 800 µg/L(parts per billion)" while "results (must) be consistent with the required 10 µg/L." (exhibit 20, p.71)
 - January 12, 1990, Mr. Salbach sent a letter to Uniroyal indicating that "despite these restrictions (Emergency Order, December 30), continued sampling of the downstream water supplies show that NDMA levels were persisting at or above the Ministry guideline." (exhibit 20, p.90)
 - January 12, 1990, Uniroyal filed a request for a hearing before the Environmental Appeal Board.
 - January 18, 1990, Uniroyal was ordered (Appendix E) to discontinue immediately any discharge into the Municipal Sewage Treatment Plant in Elmira. (exhibit 3) This order was based on two samples obtained by the MoE from the Elmira STP: one sample taken January 12, 1990 was reported to contain 0.8 µg/L NDMA and another sample taken January 15, 1990 was reported to contain 0.59 µg/L NDMA.
 - January 19, 1990, Uniroyal requested a hearing before the Environmental Appeal Board with respect to the whole of the Emergency Direction and the Director's Notice of January 18, 1990 in addition to the matters raised in letters of January 12, 1990 and January 17, 1990 concerning testing protocols.

- January 19, 1990, Uniroyal submitted a proposed shut-down and start-up plan to the Ministry of the Environment. (exhibit 20, pp. 108-111)
- January 23, 1990, Mr. R. C. Stewart, MoE, outlined the process by which the criteria for calculation of allowable concentrations from Elmira STP were developed. (exhibit 9)
- January 24, 1990, the Environmental Appeal Board commenced the Hearing. The Hearing was adjourned on the same day to permit Uniroyal to negotiate with the Ministry of the Environment and to implement an NDMA Abatement Plan submitted by Uniroyal to the MoE.
- January 24, 1990, Uniroyal submitted its NDMA abatement plan to the Ministry of the Environment for approval. (exhibit 81)
- January 25, 1990, Uniroyal presented an abatement plan for testing and disposal of waste water. (exhibit 38)
- January 26, 1990, the Director approved Uniroyal's NDMA Abatement Plan and advised Uniroyal the company must comply with the plan (appendix F).
- January 30, 1990, Uniroyal presented a proposal to the MoE for NDMA testing. (exhibit 39)
- January 31, 1990, the discharge of wastewater from Uniroyal to the Elmira STP was reported to contain 2,300 µg/L of NDMA. (exhibit 140)
- February 1, 1990, Mr. M. Ethier of the MoE expressed a concern to Mr. D. Ireland about the staff sampling procedures, especially for legal purposes. (exhibit 33)
- February 2, 1990, a Notice (Appendix G) was issued by the Director, Hamilton Regional Office, Ministry of Environment, that NDMA was detected in the Elmira STP and that Uniroyal was ordered to discontinue discharges to the STP. (exhibit 3)
- February 8, 1990, Uniroyal requested permission for the emergency release of rainwater from one of its holding ponds, RPW8. (exhibit 105, #1)
- February 15, 1990, the Ministry refused permission for Uniroyal to discharge existing contents of RPW8 into the Canagagigue Creek because the pond contained measurable levels of NDMA and Uniroyal had not provided analyses for organo-chlorine pesticides, phenols or total dissolved solids in this pond, which had been requested in the MoE letter of February 7, 1990 to Uniroyal. (exhibit 82)
- February 16, Weir & Foulds sent a letter to the MoE, again requesting permission to release rainwater from RPW8 into Elmira STP. (exhibit 105, #2)

- February 16, 1990, the Ministry again refused permission to discharge the RPW8 rainwater. (exhibit 105, #5)
- February 22, 1990 the test results became available for the rainwater in RPW8. Uniroyal requested permission to release water from RPW8. (exhibit 107, #7)
- Mr. Salbach informed Uniroyal of the need for activated carbon treatment before release of water from RPW8, and on March 7, 1990, Uniroyal requested test results of rainwater and ordered an activated carbon treatment column for RPW8. (exhibit 9, #10)
- March 29, 1990, Uniroyal requested permission to discharge treated waste water. (exhibit 105, #11)
- March 29 and April 6, 1990, Uniroyal requested permission to discharge rainwater.
- April 20, 1990 permission was granted by the Ministry to discharge rainwater under specified conditions (exhibit 16) with discharge predicted to begin on April 30, 1990.
- On July 3, 1990, the Ministry presented a Revised Part 3 - Emergency Direction outlining the changes in the Emergency Order dated December 30, 1989 that it considered necessary. (exhibit 106) This draft Direction was never formally issued by the Director to Uniroyal. However, it did form the basis for discussion between the parties which eventually led to the Board issuing an Interim Order on September 6, 1990.
- On July 23, 1990, Uniroyal requested the discharge of specific batches of treated wastewater. (exhibit 107)
- Uniroyal, in agreement with the Regional Municipality of Waterloo, Township of Woolwich and the Ministry of Environment, proposed a motion, dated August 13, 1990, to the Environmental Appeal Board (exhibit 123), that would allow Uniroyal to commence discharging its wastewater to the Elmira STP provided that the wastewater met specific criteria that would be defined in an Interim Order which the proposing parties suggested should be issued by the Board.
- September 6, 1990, the Environmental Appeal Board issued its INTERIM ORDER, with reasons, amending the proposed motion to the Environmental Appeal Board, dated August 16, 1990. This allowed Uniroyal to commence controlled batch discharges of wastewater after the wastewater had been tested for NDMA and its discharge approved by the MoE.

EVIDENCE:

Synthesis of the evidence was complicated by the fact that the Board sat for 32 days - including some evening sessions - hearing evidence from thirty witnesses through examinations, cross-examinations, and re-examinations by the counsel representing the six parties, and questions from the Board; arguments by counsel for the parties; plus seven statements by representatives from the public-at-large - all over the period from January to December 1990. Because of scheduling problems for the Hearing dates and witness appearances, it was often not possible for the parties to complete their evidence without interruption. For example, Dr. Nestmann testified on seven different days including two evening sessions, over a period of two months. His testimony was interrupted on four occasions and interspersed with his testimony, five other witnesses were examined, cross-examined and re-examined, seven members of the public made statements and the conditions of an interim order were discussed.

Examinations, and cross-examinations in particular, were sometimes indirect, unfocussed, circuitous and repetitive. In reviewing the evidence, the Board was faced with 6376 pages of transcript, 157 exhibits and hundreds of pages of notes taken by Board members. Many pages of the transcript were occupied with objections, qualifications and attempts by counsel to present evidence. On balance, counsel were very sympathetic towards accommodating each other's and the Board's scheduling problems and understanding the Board's frustrations at times. Nevertheless, this was a Hearing complicated by a great deal of evidence, given over a long period of time in a sometimes convoluted manner. The following summary of evidence can therefore only be regarded as a summary. The Board has attempted to highlight evidence on major issues brought forward in as coherent a way as it could. Extensive reference is therefore made to the transcript and exhibits. The evidence is summarized to the extent possible by category of issues.

The evidence indicated that NDMA is considered a potential human carcinogen - a chemical compound known to cause cancer in animals and suspected of being able to cause cancer in humans. It is formed by the combination of nitrites and amines. NDMA is found in varying concentrations in a wide variety of foods and beverages, as well as in many other places including: inhaled air, mainstream and sidestream smoke from cigarettes and other tobacco products; in various commercial pesticides used in agriculture, hospitals and homes; in detergents, solvents, textiles and cosmetics; in municipal sewage sludge; and in the human body (exhibit 133).

1. DETERMINATION OF ALLOWABLE NDMA CONCENTRATION IN DRINKING WATER

1.1 Risk Level

Evidence on the determination and evaluation of risk levels was given by many witnesses including Dr. Burnett, Ms Vajdic, Dr. Lijinsky, Ms Meek, Dr. McLeish, Dr. Brecher, Dr. Nestmann, and Dr. Thompson; and from the public. Three major issues emerged:

- (i) whether it is possible to attain a zero level of risk;
- (ii) whether a zero or non-zero level of risk is appropriate; and,
- (ii) what is an acceptable level of risk if a non-zero level of risk is appropriate or if zero risk is unattainable.

Dr. Lijinsky testified that nitrosamines have been extensively tested for toxicity, and it has been found that:

- (i) they cause cancers in many different animals;
- (ii) they are among the most potent and broadly acting carcinogens; and
- (iii) NDMA is one of the most potent of the nitrosamine compounds, of which even the lowest doses cause cancer in animals.

He testified that the higher the dose of NDMA, the higher the incidence rate and the sooner the onset of cancer. Dr. Lijinsky stated that there is no safe level of NDMA in air or water that can be determined scientifically and that no one chemical agent by itself causes cancer. He further testified that certain subsets of the population, such as infants, are more sensitive to NDMA exposure. Dr. Lijinsky expressed his opinion that if it were economically and technologically feasible, the desirable concentration of NDMA in drinking water would be zero.

Ms Meek testified that the position of Health and Welfare Canada is that NDMA concentration in drinking water should be as low as possible, preferably non-detectable.

Ms Sheila A. Prociw and Ms Mary Ragula, members of the Elmira community, both stated that the desirable goal is zero discharge of NDMA.

The definition of 'acceptable' levels of discharge was perplexing throughout the Hearing. The toxicological evidence was based on 'de minimis' or 'negligible risk' which is the probability of an individual in the population contracting the most sensitive endpoint (carcinoma in the case of NDMA ingestion or inhalation) from a lifetime exposure to the chemical. In other words the risk of developing cancer from exposure to the chemical through ingestion or inhalation over a lifetime.

The rationale is that if this probability is 'very small' then the risk is 'negligible'. Most of the toxicological evidence suggested that risk levels of one chance [or occurrence] in 100,000, or one chance in 1,000,000, were commonly used in scientific

assessments. These risk levels are often referred to as 10^{-5} - that is, one chance in 100,000, and 10^{-6} representing one chance in 1,000,000.

To further complicate the testimony about risk levels, evidence showed that individuals may be exposed to NDMA through several different sources such as: skin contact, inhalation, ingestion of foods and drinking water, and endogenous production. Dr. Brecher testified that in his opinion, risk levels of 10^{-5} from all sources of NDMA exposure and 10^{-6} for drinking water exposure to NDMA would be appropriate for setting standards but that the selection of a risk level is a matter of public policy. Dr. Nestmann stated that a risk level of 10^{-5} for drinking water exposure to NDMA is appropriate and that it is inappropriate to partition the risk among the different sources of exposure. Ms Vajdic testified that drinking water standards are normally developed at risk levels between 10^{-5} and 10^{-6} . Dr. Thompson stated he would personally consume drinking water with a risk level of 10^{-4} . Dr. Lijinsky testified that if an NDMA concentration of zero were not possible to achieve, then drinking water standards should be determined very conservatively.

All of the scientists who gave toxicological evidence were in agreement that the determination of an acceptable level of risk for drinking water is a public policy issue rather than a scientific issue.

1.2 Toxicological Assessment

The purpose of a toxicological assessment of a chemical is to determine the risks to human health associated with various levels of exposure to the chemical. The goal of this process is to associate levels of risk with various concentrations of the chemical in drinking water. The process includes the following steps:

- (i) gather data from animal experiments in which the animals are exposed to high doses of a chemical;
- (ii) examine the resulting pathological effects to determine the most sensitive pathological endpoint;
- (iii) decide which tumour types should be taken into account in determining risk when the endpoint is carcinoma;
- (iv) apply a risk-dose model to the experimental data;
- (v) determine the slope factor from the risk-dose model;
- (vi) extrapolate risks from the high doses given in the animal experiments to the low dose range;
- (vii) apply a body scaling factor to adjust the animal dose to human scale and biological conditions;
- (viii) adjust the dose according to the ratio of animal to human lifetime; and
- (ix) reference the dose to per-capita drinking water consumption.

1.2.1 Epidemiological data

Evidence was presented that a variety of data sets have been used for toxicological assessments of NDMA by a number of researchers including Druckrey (1967), Terracini (1967), Lijinsky and Reuber (1984) and Brantom et al (1978). The evidence was in agreement that the Brantom et al (1978) data set is the most comprehensive, complete and valuable data set on which to base toxicological studies of NDMA.

1.2.2 Pathological endpoint

Pathological endpoints are the diseases that result from exposure to agents such as chemical toxins. Ms Meek testified that while the epidemiological data was checked for foetotoxicity and teratogenicity, carcinogenicity was found to be the most sensitive endpoint. This conclusion was corroborated by the testimony of Dr. Brecher and Dr. Nestmann. Dr. Lijinsky's testimony primarily concentrated on the carcinogenicity of NDMA.

1.2.3 Tumour types

Dr. Nestmann stated that in the Brantom study, the liver was the target organ when NDMA was ingested at low concentrations and that nine types of tumours were produced: hepatic nodules, hepatocellular adenomas, hepatocellular carcinomas, haemangiomas, haemangiosarcomas, biliary cystadenomas, bile-duct carcinomas, K-cell tumours, and a type referred to as 'uncertain'.

Dr. Nestmann testified that only treatment-related tumour types which are statistically significant in number should be included in the data set for analysis and that CanTox applied the Mantel-Haenszel Trend Test and Fisher's Exact Test to the Brantom data for each liver tumour type to determine the statistical significance of the different tumour incidences. This analysis indicated that only hepatocellular adenomas and carcinomas, haemangiosarcomas and biliary cystadenomas were statistically significant in the Brantom data. Dr. Nestmann concluded that since the hepatocellular adenomas and carcinomas are histogenically similar, the incidence data on these tumour types should be combined for analysis; however, since hemangiosarcomas and biliary cystadenomas are histogenically different from each other, as well as from the hepatic adenomas and carcinomas, the incidence data on these tumour types should be analyzed separately. He further stated that the subsequent analysis revealed that the highest risk is associated with the hepatocellular adenomas and carcinomas in male rats and with biliary cystadenomas in female rats. Dr. Nestmann testified that the inclusion of statistically insignificant or biologically unrelated tumours may result in the calculation of a less conservative risk level by diluting the slope factor. Dr. Nestmann acknowledged that the calculations made by Dr. Crump using the same approach but including all tumour types resulted in a slope factor 1.6 times larger than that calculated by Dr. Nestmann.

Dr. Brecher testified that since there is no direct evidence on the type of cancer caused by NDMA in humans, the most relevant tumour type is not known and therefore all tumour types should be considered. He noted that a toxicological investigation conducted by Health and Welfare Canada used total hepatic tumour incidence including hyperplastic nodules and that the U.S. EPA used total tumour incidence excluding hyperplastic nodules. Dr. Brecher recommended excluding hyperplastic nodules because there is no proven direct link between hyperplastic nodules and eventual cancer development; and hyperplastic nodules in and of themselves are not life-threatening.

Ms Meek testified that Health and Welfare Canada used tumour incidence in male rats only because this incidence was higher in the low dose groups as opposed to a lower incidence of tumours in female rats when exposed to low doses. Inclusion of female rat tumour incidence would produce a lower slope factor and a correspondingly lower perceived threat of disease resulting in a less conservative risk level for male rats.

1.2.4 Risk-dose model

Extensive evidence was heard on the application of various risk-dose models to tumour incidence data including:

- (i) the linear multistage extrapolation (LMS) model;
- (ii) the Weibull multistage model (also referred to as the Weibull model, the double Weibull model, the Weibull extra risk model and the Weibull time-to-tumour model); and
- (iii) the model-free extrapolation method (MFX) (also referred to as the robust linear extrapolation method and the linear robust extrapolation method).

Dr. Brecher testified that the U.S. EPA recommends that the linear multistage model be used, in general, for low-dose extrapolation but that the U.S. EPA toxicological analysis for NDMA was based on the Weibull model because good time-to-tumour data was available. Dr. Brecher supported the use of the Weibull model for low-dose extrapolation to determine risks associated with NDMA consumption in drinking water.

Dr. Nestmann recommended the linear multistage extrapolation model as the most suitable for low-dose extrapolation. He stated that a satisfactory model should have a physiological basis that is consistent with the mechanisms of carcinogenesis for the compound under consideration and that the linear multistage model is best suited to this requirement.

Dr. Brecher disagreed with Dr. Nestmann's assertion because models are intended to mimic reality and the Weibull model, although it does not have a basis in physiology, provides an excellent fit to the data. Dr. Brecher noted that although the linear multistage model has a physiological basis, its assumptions can never be

verified. He further noted that the model-free extrapolation method used by Health and Welfare Canada has no basis in physiology.

At the time that she testified, Ms Meek stated that Health and Welfare Canada did not endorse the time-to-tumour model applied by Dr. Peto and that time-to-tumour data is uncertain because it is determined through feel rather than by dissection.

Evidence was heard that a meeting of toxicological experts involved with this Hearing was held on June 15, 1990, in Ottawa, Ontario to attempt to find consensus on appropriate toxicological methods to be used in the assessment of NDMA in drinking water. A consensus was formed that the Brantom data was the most appropriate set. However, no consensus was gained on the most appropriate model to be applied to the data.

1.2.5 Determination of slope factor

Whatever the modelling approach adopted, the purpose remains the same, to establish a 'slope factor' which relates risk level to dose level in a linear fashion at low-dose levels. As a result of the different tumour incidence data selected and the low-dose extrapolation model applied, the resulting slope factors were highly divergent. (See Section 1.5 for a discussion of the results.)

1.2.6 Dose scaling

The application of a risk-dose extrapolation model is used to estimate the lifetime dose of NDMA corresponding to a risk level during the life of a rat. This dose must then be scaled to humans to account for human body size, human lifetime, and any metabolic differences between rats and humans.

1.2.6.1 Body size

Evidence was heard that the customary human body mass used in toxicological assessments is 70 kg in relation to a rat body mass of 250 g. There was no dissention on these values.

1.2.6.2 Lifetime

There was consensus in the evidence heard that the customary human lifetime used in toxicological assessments is 70 years. However, testimony on the appropriate lifetime of a rat ranged from 2 to 3 years. Dr. Nestmann testified that he used a 2 year rat lifespan in his calculations because that is a standard lifespan used in toxicological risk assessments as a normal rat lifetime. Under cross-examination by Mr. Poch, Dr. Nestmann was referred to results from the Brantom study cited in

the paper by Peto et al (1984) and agreed that over half of the subject rats in the Brantom study survived beyond 2.5 years and some beyond 3 years.

Dr. Brecher testified that the U.S. EPA toxicology study on NDMA used a rat lifespan of 3 years as reported in IRIS '88. Dr. Nestmann stated his own disagreement with this lifespan and cited Dr. Crump's opinion that this lifespan is unconventional. Dr. Nestmann testified that it is his understanding that Health and Welfare Canada uses a 2 year rat lifespan in their risk assessments.

Ms Meek testified that not all bioassays are conducted over the full lifetime of rats and that, in Health and Welfare Canada studies, they are generally done for a two-year period and then the animals are sacrificed and tumour incidence is determined. She further testified that in the Brantom study, the animals were exposed over their lifetimes because they wanted to study time-to-tumour development. Under cross-examination by Mr. Millar, Dr. Lijinsky agreed that the normal lifetime of a rat used in these kinds of studies is two years.

1.2.6.3 Body surface area correction

Evidence was heard that basal metabolism rates vary from species to species and from animal to animal. If carcinogenesis is related to basal metabolism rates, then appropriate correction factors must be applied in risk assessments. When appropriate, this correction factor is based on the ratio of body surface area to body weight wherein the body surface area is taken as proportional to the cube root of body weight (mass). Ms Meek testified that the resulting correction factor is 6.5 [i.e., $(\text{human body mass}/\text{rat body mass})^{1/3}$ or $(70,000 \text{ g}/250 \text{ g})^{1/3} = 6.5$].

Dr. Nestmann testified that the metabolism or biotransformation of NDMA is sufficiently well-known to conclude that it is not connected with basal metabolism and, therefore, it is not appropriate to apply a body surface area correction factor. Dr. Nestmann stated that the body surface area correction is appropriate to use if biotransformation of the compound is linked to basal metabolism, but that NDMA is metabolized by the P450 enzyme, and the P450 enzyme metabolic system is not directly linked to the basal metabolism system. Therefore, in his view, it is not appropriate to apply the body surface area correction factor in toxicological assessments involving NDMA metabolism.

Dr. Nestmann further testified that there are two enzyme systems which can act on the NDMA molecule, both of which are mediated by P450 enzymes. One system acts on the methyl group by demethylating the NDMA molecule which is the activation pathway and which leads to the active metabolite that can react with DNA and other molecules. The other system works through a nitroso group rather than the methyl group from the NDMA molecule which is the deactivation pathway and which leads to nonreactive metabolites. Dr. Nestmann stated that these are the only pathways during normal NDMA metabolism. Dr. Nestmann acknowledged that other researchers have suggested that in addition to methyldiazonium,

formaldehyde and other reactive metabolites may be involved in NDMA carcinogenesis.

Dr. Brecher stated his understanding that both the U.S. EPA and Health and Welfare Canada applied the body surface area correction factor in their toxicological assessments of NDMA. Dr. Brecher also stated that, in his opinion, all of the mechanisms of NDMA carcinogenesis in humans have not been conclusively demonstrated, and therefore, it cannot be definitively stated they are unrelated to basal metabolism. Therefore, in his opinion, it is prudent to apply the surface area correction factor.

Dr. Burnett testified that the body surface area correction factor was applied in the NDMA toxicological assessment performed by Health and Welfare Canada.

Dr. Lijinsky testified that the mechanisms of carcinogenesis are not known and stated the following:

"Our concept is, and we really don't know the mechanism of carcinogenics, we are beggars of action in intimate terms, of any carcinogen including nitrosodimethylamine and this is after enormous amounts of work because cancer is -- carcinogenesis is a process which takes so long and involves relatively few cells and it's very hard to study, the process, and elucidate the mechanism, ... This is a very ill-understood area..." (pp.1308-1309)

" ... if you studied metabolism in human tissue, metabolism of a carcinogen and take nitrosodimethylamine; it tells you about the metabolism of nitrosodimethylamine. It doesn't tell you that that metabolism that you have observed is related to carcinogenesis. The fact that one of five or six pathways is followed in -- one of say five or six pathways of metabolism of a particular carcinogen leads to carcinogenesis doesn't mean you can observe -- you can look at all five and six and say which one is related to carcinogenesis. It's simply an unknown, ill-understood at the moment." (p.1364)

" ... and I could pass a comment on that and that is in spite of the more than 2,000 papers published we still don't know how nitrosodimethylamine induces cancer, which is not a great tribute to our technology I'm afraid." (p.1367)

1.2.7 Per capita drinking water consumption

The amount (mass) of chemical ingested by drinking water is determined by its concentration in the water and by the volume of water consumed. Evidence was led on the appropriate value of daily per capita water consumption to be used in toxicological studies.

Dr. Burnett and Ms Meek both testified that, in their toxicological assessments of NDMA for Health and Welfare Canada, an average drinking water consumption of 1.5 litres per capita per day (Lpcd) was used.

Dr. Brecher testified that the U.S. EPA uses a drinking water consumption rate of 2.0 Lpcd and that the statistics on drinking water consumption in Canada available to him revealed that about 1/3 of the population consumes more than 1.5 Lpcd and up to 16% consumes more than 2.0 Lpcd. For this reason, he prefers to use the rate of 2.0 Lpcd in toxicological assessments of drinking water.

Dr. Nestmann testified that the toxicological assessment performed by CanTox used the consumption rate of 1.5 Lpcd adopted by Health and Welfare Canada.

1.2.8 Average vs. more sensitive group of the population

Witnesses were questioned on whether the toxicological assessments of drinking water should be based on the average individual of the population or some more sensitive subset of the population, particularly the fetus and infants.

Dr. Lijinsky testified that he considered infants to be more susceptible to health risks from NDMA exposure and, similarly, individuals with previous exposure to carcinogens. He stated that he had not taken these more sensitive individuals into account in his own calculations in dose-response studies.

Ms Meek stated that, although risk assessments are undertaken for the average individual, the assessments are based on very conservative assumptions which would be protective of the more sensitive individuals in the population. Dr. Brecher testified that all of the risk assessments of NDMA exposure which he has seen have addressed the risk from lifetime exposure. Evidence was heard that sensitivity to NDMA exposure may vary between males and females, with age and with exposure to other chemical agents.

1.2.9 Synergistic effects

Several witnesses were questioned on their knowledge of synergy which may take place when the individual is exposed to NDMA in conjunction with other chemical agents. There was general acknowledgement that such synergy is possible but that little is known and that toxicological assessments are usually performed on a chemical-by-chemical basis.

1.3 Alternative NDMA Exposure Pathways

Evidence was heard on alternative pathways of NDMA exposure including: inhalation, ingestion of food and drink, and endogenous NDMA production.

1.3.1 NDMA inhalation

Testimony was given that the inhalation of NDMA from mainstream and sidestream tobacco smoke, etc., poses a significant risk, similar in effect to ingestion of NDMA in drinking water, but generally resulting in different tumour types.

1.3.2 NDMA ingestion in food and drink

Much evidence was heard that NDMA exists in a variety of foods and over a wide range of concentrations. Dr. Nestmann cited a range of dietary intake of NDMA from 0.29 to 1.8 µg/person/day.

1.3.3 Endogenous NDMA production

Dr. Lijinsky testified that nitrites and amines present in the stomach can combine to form nitrosamines, however, he gave no opinion as to the quantity that could be produced.

Dr. Nestmann cited a range of endogenous production of NDMA from 25 to 1800 µg/person/day. He further cited Dr. Brantom's suggested range of 10 to 180 µg/person/day. Dr. Nestmann stated that the potential sites where the nitrosation of amines by nitrite can occur include the oval cavity, the stomach, the intestines, and the urinary bladder, and that endogenous nitrosation of amine could occur by chemical reaction in an acidic environment, and by bacterial action in a neutral environment. Dr. Brecher testified that he was not aware of any method to directly measure the endogenous production of NDMA. He further stated that certain metabolic disorders can increase the endogenous production of NDMA. Dr. Nestmann also described a method of estimating endogenous NDMA production by measuring the rate of NDMA clearance in fasting subjects.

1.4 Action Limits vs. Fixed Standards

The Board heard evidence that drinking water quality standards are customarily set at a level corresponding to the risk associated with average lifetime exposure. Ms Vajdic cited the U.S. EPA ambient water quality guidelines for NDMA as 1.4 ng/L (ppt) at a risk level of 10^{-6} and 14 ng/L (ppt) at a risk level of 10^{-5} . When asked by Mr. Berger why she recommended the 14 ppt level which would result in a risk

level of 10^{-5} instead of the 1.4 ppt level which would result in a risk level 10^{-6} for the interim guideline, she stated:

"...We like to keep the risk level when we develop drinking water quality guidelines between 1 in 100,000 and 1 in a million. In the case of the NDMA the 14 ng/L level is associated with, if you will, maximum acceptable risk which is 10^{-5} or 1 in 100,000. However, in the Elmira situation there were a couple of additional factors that I took into account when I recommended that 14 ng/L level. One was that at the time we did not anticipate the exposure to the chemical would be a lifetime exposure, we felt that the exposure would be somewhat less than a lifetime ... We considered this, if you like, an emergency situation with the chemical just being identified in the groundwater and given the information that I had at the time I felt that the chemical probably had not been present in the groundwater ... Had not been present in the ground for a period of 70 years, which is the normal period of time to describe lifetime exposure."
(pp.839-340)

Dr. Nestmann testified that some regulatory agencies in the United States are considering short-term action limits for contaminants in drinking water which allow for higher concentrations of the contaminant over short periods of time under specific conditions.

1.5 Resulting Drinking Water Standards for NDMA

On November 14, 1989, Ms Ann Vajdic of the Drinking Water Section, Water Resources Branch, Ontario Ministry of the Environment, wrote to Dr. Richard Tobin of the Monitoring and Criteria Division, Health Protection Branch of Health and Welfare Canada requesting an assessment of health effects of exposure to NDMA. In addition to toxicological information on NDMA, Dr. Tobin indicated in a letter of November 19, 1989 to Ms Vajdic that the U.S. EPA estimates of increased cancer risks from NDMA concentrations in ambient water and the resulting additional intake in fish and shellfish at the 10^{-5} , 10^{-6} , and 10^{-7} levels were 14, 1.4, and 0.14 ng/L, respectively, but that he was unable to comment on the validity of those estimates (exhibit 2b). It was later revealed that these estimates were based on the bioassay data of Druckrey (1967) (exhibit 112). On November 15, 1989, Ms Vajdic wrote to Mr. Steve Salbach, Acting Director, Hamilton Regional Office, Ontario Ministry of the Environment, indicating the above U.S. EPA guidelines and indicated that the criterion of 14 ng/L at a risk level of 10^{-5} was felt to be appropriate for the Elmira situation (exhibit 15).

Ms Vajdic testified that Dr. Tobin wrote to her on January 10, 1990, indicating that Health and Welfare Canada had further reviewed and evaluated relevant data and that as a result recommended an interim guidance value of 12 ng/L at the 10^{-6} lifetime risk level for NDMA in drinking water. [Dr. Burnett had previously

testified that this value was calculated using the Terracini (1967) data with the Linear Robust Low Dose Extrapolation Method (model-free extrapolation method) and applying the body surface area dose scaling factor.] Dr. Tobin also indicated that Health and Welfare Canada was awaiting the receipt of more extensive bioassay data from the U.K. (later revealed to be the BIBRA - Brantom (1978) data in exhibit 112) and that this latest interim guidance value may be revised as a result of the assessment of that data (exhibit 5). Ms Vajdic indicated that the guideline value of 14 ng/L was not changed to 12 ng/L upon receipt of this information because these two values were not analytically distinguishable with the laboratory equipment available at the time.

Ms Vajdic stated that recent inquiries of the U.S. EPA indicated that a new U.S. EPA assessment of NDMA (later revealed to be based on the Brantom (1978) data) would result in their ambient water quality guideline being revised to 7 ng/L at the 10^{-5} risk level.

Ms Meek testified that on May 1, 1990, Dr. Tobin wrote to Dr. Ken Roberts, who was then the Manager of the Drinking Water Section, Water Resources Branch of the Ministry of the Environment, indicating that more recent risk assessments of NDMA in drinking water had been performed by Health and Welfare Canada. Associated with a lifetime cancer risk of 10^{-6} , a concentration of 5 ng/L was determined based on the bioassay results of Lijinsky and Reuber (1984) and a concentration of 0.04 ng/L was determined based on the bioassay results of Brantom (1983). Since these concentrations were below the 10 ng/L detection limit for NDMA in water that was previously reported by the Ontario Ministry of Environment, Dr. Tobin recommended that levels of NDMA in drinking water not exceed this detection limit. Ms Meek testified that the calculated values of 5 and 0.04 ng/L were based on the model-free extrapolation method.

Ms Vajdic stated that the treatability of NDMA was not considered in setting the interim drinking water quality guideline but that it would be considered when moving from an interim to a final guideline.

Dr. Brecher gave evidence that following the U.S. EPA methodology for risk assessment of NDMA in drinking water, the slope of the dose response curve was determined to be 51 mg/kg/day. [This calculation was derived using the Weibull time-to-tumour model, the Brantom data on total liver tumour incidence in female rats excluding hyperplastic nodules, the body surface area correction factor, and a rat lifespan of 3 years.] Based on this slope factor, the following NDMA concentrations in drinking water were determined at the risks noted:

at a drinking water consumption rate of 1.5 Lpcd:

0.91 ng/L at 10^{-6} risk level

9.1 ng/L at 10^{-5} risk level

at a drinking water consumption rate of 2.0 Lpcd:

0.68 ng/L at 10^{-6} risk level

6.8 ng/L at 10^{-5} risk level.

Dr. Nestmann testified that the CanTox methodology for risk assessment of NDMA in drinking water resulted in NDMA concentrations in drinking water of 205.6 ng/L at the 10^{-5} risk level and 20.56 ng/L at the 10^{-6} risk level (using the linear multistage model, the Brantom data on hepatocellular adenomas and carcinomas in male rats and biliary cystadenomas in female rats, a drinking water consumption rate of 1.5 Lpcd, a rat lifespan of 2 years, applying body weight rather than surface area correction, and averaging the slope factor between males and females).

2. QUANTITATIVE CHEMICAL ANALYSIS FOR NDMA

Much evidence was led on aspects of quantitative chemical analysis for NDMA in water and sewage samples. The concentrations of NDMA discussed in testimony range from the milligram to microgram to nanogram to even the picogram per litre levels. Other issues included type, accuracy and precision of the instruments, equipment detection limits, analysis and sampling protocols and the method of determining compliance.

2.1 Instruments for Chemical Analysis of NDMA

Most of the testimony focussed on three different instruments for conducting the chemical analysis of NDMA. The three units that were discussed are as follows:

- (i) gas chromatography/low resolution mass spectrometry (GC/LRMS);
- (ii) gas chromatography/high resolution mass spectrometry (GC/HRMS); and
- (iii) thermal energy analysis (TEA).

Dr. Vincent Taguchi, Supervisor of the Mass Spectrometry Unit at the Ontario Ministry of the Environment (MoE), stated that the MoE laboratory used GC/LRMS to analyze samples for NDMA until December 1989 after which time (approximately December 22, 1989) GC/HRMS was employed. Dr. Taguchi stated that both the GC/HRMS and TEA methods are very selective for NDMA but that the TEA method has a drawback related to the methodology used for its internal calibration. A great deal of testimony was devoted to the very complex and sensitive calibrations required to adjust these highly technical instruments which are used to perform the chemical analysis of NDMA to ensure the accuracy of the analyses.

Dr. Meresz testified that he would recommend the TEA for screening but not for confirmation and that he would rely on mass spectrometry for confirmation.

Dr. Lijinsky stated that:

"...the GC/HRMS method as applied is a good method, but I just think it's cumbersome and expensive, but having details of the method, I do believe that the GS/HRMS as used or recommended is a good method of detection

and measurement of NDMA. I don't believe, however, that it is sufficiently sensitive and it's very expensive and cumbersome." (p.1270)

Dr. Lijinsky noted that in exhibit 27 which outlined the MoE protocol for NDMA analysis with the GC/HRMS, the concentration of the marker compound, d₆-NDMA was indicated to be 40 ng/L, which is much higher than the 1.4 or 0.65 ng/L NDMA concentration under detection, and would decrease the sensitivity of the method at lower levels of detection. Discussing the relative sensitivities of the GC/HRMS and the TEA methods, Dr. Lijinsky stated:

"...just tell me the method is as sensitive as I know the TEA method is, because I have used the TEA myself and I haven't used the mass spectrometry." (p.1427)

Mr. King testified that because of the linearity of the ratio of NDMA to d₆-NDMA over a range of concentrations found in Dr. Taguchi's analysis, he believed that the data was proven to be good and that the 40 ng/L concentration of the d₆-NDMA marker was not a real concern. Mr. King presented the results of a round-robin interlaboratory study on NDMA analysis including tabulated results and control charts. Asked whether he was comfortable with the use of TEA for NDMA analysis as opposed to GC/HRMS analysis based on the interlaboratory study results, Mr. King replied that he was comfortable with this, except for the lower concentration range. Mr. King stated that he had not personally used the TEA or the GC/HRMS instruments. He also stated that the GC/HRMS does not encounter interference from matrix samples.

Dr. Riggs testified that the experience of the Uniroyal Chemical Ltd. laboratory in Guelph was that the TEA method is less suited for quantitative analysis of NDMA than mass spectrometry as it cannot compensate for the wildly varying extraction efficiencies. In reply to a question on the analysis techniques he recommends for NDMA determination, Dr. Riggs replied:

"I think that the mass spectrometry is the way to go, I think the mass spectrometry right now is demonstrated to be superiority (sic) to TEA." (p.5167)

2.2 Round-Robins

Evidence was heard throughout this Hearing on results of NDMA analyses of water and sewage samples that were performed by different laboratories using different analysis instruments.

In general, NDMA analysis was a relatively recent undertaking of the laboratories and the analysis of such low concentrations in the ppt range was just becoming state-of-the-art in these laboratories. Therefore, the need for round-robin interlaboratory comparisons was apparent. Round-robins are a carefully defined method of simultaneously comparing the analysis results on the same sample of a

chemical compound by several different laboratories, thereby ensuring that each laboratory is able to correctly perform future analyses of the chemical compound.

The laboratories involved in the round-robins were:

- | | |
|--|---|
| 1(a). Ministry of Environment | GC/HRMS laboratory (Dr. Taguchi); |
| 1(b). Ministry of Environment | GC/LRMS laboratory (Mr. Hall); |
| 2. Environmental Canada | HRGC/LRMS; |
| 3. Ecologic | GC/LRMS; |
| 4. Canviro Analytical Laboratories | GC/LRMS; |
| 5. Ortech International | GC/TEA; |
| 6. Uniroyal Chemical Inc. (Connecticut laboratory) | GC/HRMS; |
| Uniroyal Chemical Ltd. (Guelph laboratory) | GC/LRMS; GC/TEA; |
| 7. Concord | gas chromatograph/ion trap detector (GC/ITD); |
| 8. Semoptics Ltd. | GC/HRMS. |

In addition, different GC columns were employed by the laboratories.

Round-robins were coordinated by Mr. King and his staff from the Quality Assurance Unit, Laboratory Services Branch of the MoE. The first round-robin interlaboratory study (#90-1) was conducted in March, 1990. Results for this study are in a memorandum and attachment from Mr. King to Mr. Berger dated April 30, 1990 (exhibits 62 and 63). The samples used in this study were dilutions of standard NDMA solutions with HPLC (ultra pure) water. The participating laboratories were:

1. MoE (Dr. Taguchi);
2. MoE (Mr. Hall);
3. Environment Canada;
4. Ecologics;
5. Canviro (two different GC columns, one LRMS);
6. Ortech;
7. Uniroyal Connecticut; and
8. Uniroyal Guelph (GC/LRMS and GC/TEA).

Results of a second round-robin interlaboratory study and linearity study (#90-2) were presented in a memorandum and attachments from Mr. King to Mr. Berger dated June 7, 1990 (exhibit 121). The samples used in this study were also NDMA-spiked HPLC water. The participating laboratories were:

1. MoE (Dr. Taguchi);
2. MoE (Mr. Hall);
3. Environment Canada;
4. Ecologic;
5. Canviro;
6. Ortech;
7. Uniroyal Connecticut;
8. Uniroyal Guelph (GC/LRMS and GC/TEA); and
9. Semoptics.

Results of the third round-robin interlaboratory study (#90-3) were presented in a letter from Ms Cussion of the Quality Management Unit, Laboratory Services Branch of the MoE to study participants dated August 7, 1990 (exhibit 120) and an

attachment being a hand-drawn Youden plot by Mr. King (exhibit 122). The samples used in this study were NDMA-spiked Elmira STP influent. The laboratories contributing results were:

1. MoE (Dr. Taguchi);
2. MoE (Mr. Hall);
3. Environment Canada;
4. Ecologic;
5. Canviro;
6. Ortech; and
7. Uniroyal Connecticut.

The Uniroyal Guelph laboratory could not provide results during the last round-robin interlaboratory study because of equipment problems; Concord did not participate in the study; and two other laboratories had not reported results at the time. An additional interlaboratory study (#90-2) was conducted between the MoE laboratories of Dr. Taguchi (GC/HRMS) and Mr. Hall (GC/LRMS) and the Uniroyal Guelph laboratory (GC/LRMS and GC/TEA). The samples used in this study were NDMA-spiked samples of equalization tank and carboxin tank waters from the Uniroyal Chemical plant in Elmira. Results of this study are presented in exhibit 138.

In summary, the three round-robin interlaboratory studies produced highly divergent results.

2.3 Detection Limits, Accuracy and Precision

Dr. Taguchi testified that the detection limit, for NDMA in clean water samples, of the GC/HRMS method of the MoE was 10 ppt until the middle of January, 1990 and 2 to 3 ppt after that time. He stated (under direct examination) that, on the basis of tests performed on spiked matrix samples, the MoE GC/HRMS method was biased about 10% high at an NDMA concentration of 20 ppt, 12% high at 100 ppt, and 30% high at 1 ppt. On the basis of 8 replicate analyses at a concentration of 124 ppt, the standard deviation was less than 10% (5.9% in exhibit 27). Dr. Taguchi stated that at that time no statistical study, based on known replicates of the influent to and the effluent from the Elmira Sewage Treatment Plant (STP), had been performed to determine the variability of the MoE analysis for NDMA. Dr. Taguchi stated that prior to February 2, 1990 he did not know if the variability in the MoE NDMA analysis was different for an Elmira STP sample than for a blank sample. Dr. Taguchi further stated (under cross examination) that although he had measured the accuracy of the MoE NDMA analysis for spiked HPLC grade water, he did not measure its accuracy for the matrix. Dr. Taguchi stated (under re-examination) that he did not know the exact level of confidence in the MoE NDMA analysis by GC/HRMS but that he was confident in the results.

Dr. Meresz gave his opinion that the TEA is not as accurate as the HRMS. He also stated that he felt the accuracy of Dr. Taguchi's GC/HRMS analyses was acceptable in trace analysis and that the important issue is knowing the limitations of the

analysis. He also considered the results from Dr. Taguchi's laboratory to be reliable and that the GC/HRMS would eliminate matrix effects.

Dr. Meresz testified that he was confident that the measured NDMA concentrations of 2.1 and 3.2 ppb NDMA in the Elmira STP effluent samples taken on February 1, 1990 and January 31, 1990, respectively, showed that the true concentrations were above 0.5 ppb; but he was not confident that the measured concentrations of 0.59 and 0.62 ppb on January 15, 1990 and January 17, 1990, respectively, showed that the true concentrations were above 0.5 ppb; and that he was "just about comfortable" that the measured concentration of 0.8 ppb on January 15, 1990 showed the true concentration was above 0.5 ppb.

Under cross-examination by Mr. Buhlman, Dr. Meresz agreed that he was not in a position to disagree with Dr. Taguchi's evidence regarding what confidence he had in his NDMA analyses reported in exhibit 2J. Dr. Meresz also agreed that the analysis variability determined from spiked HPLC grade water does not give the variability of the analysis protocol for a matrix sample for STP effluent or Uniroyal effluent; however, he continued that the high degree of selectivity of the GC/HRMS would overcome any interference caused by a matrix sample.

Mr. King testified that based on the NDMA analyses results from Dr. Taguchi's laboratory, a result of 0.65 µg/L would suggest that the sample contained more than 0.5 µg/L and that he would rely on that figure for a Control Order. Mr. King indicated that, from the data available, he considered the detection limit of the MoE GC/HRMS instrument to be on the order of 3 ppt and certainly not higher than 5 ppt. Mr. King stated that the combination of the MoE analysis results for NDMA in the Elmira STP effluent on January 12, 15 and 17, 1990, which were 0.80, 0.59, and 0.62 µg/L, respectively, reinforced his conclusion that the true effluent concentrations were above 0.5 µg/L of NDMA. He further stated that the concentrations of 3.2 and 2.1 µg/L on January 31, 1990 and February 1, 1990, respectively, definitely indicated that the true effluent concentrations were above 0.5 µg/L of NDMA.

Dr. Riggs testified that the amount of d₆-NDMA used in mass spectrometry ideally should be as close as possible to the amount of NDMA that is present in the sample. He stated that Dr. Taguchi's tests for accuracy of the MoE GC/HRMS method for NDMA analysis were based on spiked reagent grade water which does not necessarily reflect the accuracy of the method for matrix samples. Dr. Riggs testified that Dr. Taguchi's determination of the precision of the MoE method was not at the levels of interest and were not performed on matrix samples. Therefore, this determination of precision possibly indicated very little about the precision of the method on matrix samples. He also stated that he would expect the precision of a method to improve with the analyst's experience. Dr. Riggs stated that the results from round-robin numbers 1 and 2 on NDMA analysis did not provide any information on the accuracy and precision of the methods used on actual matrix samples since they were conducted on spiked reagent grade water.

Dr. Borth testified that the MoE test results of spiked HPLC grade water (exhibit 27) produced estimates of variability which were unreliable for estimating the variability in measurements of NDMA concentration in a matrix sample from sewage treatment plant effluent. He further stated that, in his opinion, the MoE test results and statistical analyses of the two round-robins were insufficient to confidently quantify measurement errors.

In the NDMA analysis results reported by Dr. Taguchi's laboratory on field samples after December 1989, the lowest detection limits were cited as 5 or 10 ppt (exhibits 2J, 43, 152A, 152B, 154 and 157).

2.4 Sampling and Analysis Protocol; Quality Assurance/Quality Control

Mr. Salbach stated that the staff of the Elmira STP were taking samples at the STP during January, 1990 and that the sewage treatment plant superintendent, Mr. Ethier, had concerns about his staff taking samples for legal purposes.

Two letters from Mr. Ethier to Mr. Ireland dated January 15, 1990 and February 1, 1990 (exhibits 32 and 33) outlined some of Mr. Ethier's concerns about the STP sampling.

Mr. Salbach indicated that he had not had discussions with Mr. Ethier but did have discussions with his staff. He believed that an oral rather than a written sampling protocol had been given to Mr. Ethier.

Through witness statements from Mr. Ethier, Ms Paul and Mr. McDermott, (exhibits 34, 35 and 36, respectively), all of whom were involved with sampling at the plant, evidence was heard that samples from the Elmira STP were collected using juice cans, brought by Mr. McDermott from his home, and then composited and stored in galvanized metal pails. Ms Paul noted in her witness statement that at times the samples would freeze in the galvanized pail and the ice would have to be broken with a steel rod to take samples. Mr. McDermott indicated in his witness statement that it is possible he may have been smoking while sampling. After he was instructed on January 23, 1990 that he should not smoke while sampling, he stopped.

Mr. Ethier testified that he was instructed to obtain four galvanized steel pails each with a capacity of approximately 9 litres for use at the four sample locations in the Elmira STP. At each sampling station on the sampling day, grab samples were taken four times throughout the day at approximately two hour intervals. These samples were composited in the pails and at the end of the sample day, the contents of the pails were transferred to one-litre glass bottles which were transported to the laboratory. Mr. Ethier stated that this sampling procedure was used until approximately early February 1990, at which time a standardized protocol for NDMA sampling (exhibit 31) was received from the Water Assessment Branch of the MoE and used after that time. Mr. Ethier testified that after January 23, 1990 further precautions were instituted in the sampling method, including no smoking while

sampling and rinsing the sampling can three times in the material being sampled. Mr. Ethier also testified that he had assisted Mr. Robinson, a Provincial Officer from the Cambridge District Office, to sample the Elmira STP after hours on February 1, 1990. A split sample was taken by filling two sample bottles by judging volumes "by eye".

Mr. Vickers testified that he prepared the sampling protocol (exhibit 31) in January, 1990 and that updates to this protocol had been made since then. Mr. Salbach testified that this sampling protocol of Mr. Vickers for NDMA analysis was not given to Uniroyal by the MoE until early February, 1990 (exhibit 31).

A letter with attachments from Dr. Taguchi to Mr. Berger, dated February 26, 1990, (exhibit 27) was entered into evidence. The attachments included the protocol used by the MoE laboratory for the determination of NDMA in water and effluent by GC/HRMS. Dr. Taguchi stated that this protocol was a standard draft protocol because it did not have all of the quality assurance (QA) data to make comparisons. He further stated that this protocol had been in use since December 22, 1989. Later, the protocol was changed to include an acid wash of the sample.

Dr. Meresz testified that he thought the sampling procedure prior to February 1, 1990, which had been described by Mr. Ethier, was suitable for the purpose and he did not expect any significant difference in results at the ppb level.

Mr. Thompson testified that the Regional Municipality of Waterloo had draft protocols for sampling and analysis that had been developed by CH2M Hill (exhibit 17, tabs 15 and 16) and that these protocols were used for work on behalf of the Region. Mr. Thompson indicated that CH2M Hill was engaged in work with these protocols since early December, 1989.

Dr. Earl E. Shannon, Regional Manager, Ontario Operations for CH2M Hill, testified that he was the Project Manager of the Consulting Team for the Regional Municipality of Waterloo's Elmira/St. Jacob's water supply project. He had also been involved in several quality assurance and quality control (QA/QC) programs including the sampling and analysis of industrial and municipal effluents. One of the specialty support groups of the consulting team was for "Sampling and Analytical QA/QC Support". He stated that part of this project involved the preparation of a sampling protocol for NDMA (given in exhibit 75, tab 3) and an analytical protocol for NDMA - isotope dilution - GC/MS (given in exhibit 75, tab 4). Dr. Shannon stated that these protocols were developed from discussions with personnel at MoE, Canviro Analytical Labs, Ecologic, Wastewater Technology Centre of Environment Canada and Beak Consultants and that the analytical procedure was based on U.S. EPA methodology which was developed to detect NDMA concentrations at lower levels. Dr. Shannon noted that these protocols had been included in the Compliance Plan submitted by Uniroyal Chemical Ltd. to the Engineering Committee, Regional Municipality of Waterloo. Dr. Shannon stated that the sampling protocols did not include specific methodologies for sewage treatment plant effluents. Dr. Shannon further stated that these sampling and analysis protocols were not designed for STP samples but rather for the water supply

activities of his project team and the analysis equipment available to them, which did not include a GC/HRMS.

Dr. Riggs testified that the Uniroyal Chemical Ltd. laboratory in Guelph followed the U.S. EPA Good Laboratory Practices guidelines for the generation of valid data. He described these guidelines and stated that a validated analytical method should include measurements for accuracy, precision, linearity and detection limits. He stated that the Guelph laboratory essentially followed the MoE analysis protocol (exhibit 27) for NDMA analysis using their low resolution mass spectrometry capabilities. Dr. Riggs went on to describe how he would determine accuracy, precision, detection limit and range of linear response of an instrument with reference to exhibit 135, tab 2. He also described a protocol he had developed for NDMA analysis by GC/LRMS and GC/TEA (exhibit 136) which included a discussion of QA/QC requirements.

Mr. Clegg described what he considered to be minimum QA/QC requirements for sampling and analysis (exhibit 157).

3. CHEMICALS OTHER THAN NDMA

Dr. George Lunn testified on matters related to the treatment and degradation of NDMA and on the Uniroyal Chemical Ltd. Compliance Plan. Dr. Lunn expressed his concerns that methods of NDMA treatment could possibly produce by-products of degradation which, in themselves, might be toxic. In addition to NDMA, Dr. Lunn introduced a list of 14 other chemicals (exhibit 104) which he felt should be included in a scan of sewage treatment plant effluents. Dr. Lunn also recommended testing effluents for mutagenicity using the Ames test. After reading (exhibit 102, appendix E) the 'Interim Wastewater Treatment Plan/Compliance Plan' submitted by Uniroyal Chemical Ltd. which included a list of chemicals proposed for the effluent parameter scan, Dr. Lunn held to his opinion that his list of 14 chemicals should be added to this effluent parameter scan.

4. METHOD OF DETERMINING COMPLIANCE

The Notice of December 30, 1989 served on Uniroyal Chemical Ltd. by the Director, Hamilton Regional Office of the MoE included in the terms of compliance that:

- if any individual process effluent exceeds a concentration of 10 µg/L NDMA (sampled at least one per week); or
- if the effluent from the Elmira STP exceeds 0.5 µg/L NDMA; and
- if any detectable quantity of NDMA is present in Uniroyal sewage, discharge from Uniroyal Chemical Ltd. will cease.

Further evidence was heard that compliance should be determined by a sample averaging procedure rather than by a single sample analysis result because of the variability of NDMA sampling and analysis.

Dr. Shannon said that the averaging of sample results of STP effluent discharge was used in some instances but he is not sure how common a procedure it is and that the MoE is probably more appropriate to comment. He stated that he considered it necessary to define some level that should never be exceeded; however, he also considered it difficult to make a decision on the basis of a single test result.

Dr. Borth presented evidence on the reliabilities of single, multiple and averaged measurements in determining compliance. He established quantitative relationships on the probability of being out of compliance with respect to measured NDMA concentration as a function of the true concentration, the standard deviation of the measurement errors, and the number of samples measured, assuming a normal distribution of measurement errors. These relationships are presented graphically in exhibit 148.

Under cross-examination by Mr. Millar, Mr. Salbach indicated that whether or not averaging of sample results is used as the basis of compliance, and how these results are averaged over time, depends on the parameter being measured in an STP effluent. He continued that:

"...If one has parameters that are of a significant health risk I think the approach would be much more cautious and would be interpreted on a site specific basis...If one talks about hazardous contaminants, possibly a more stringent approach would be taken."(p.400)

Asked by Mr. Millar if he had examples of one sample being used to determine compliance, Mr. Salbach stated:

"For example, as far as the Great Lakes Agreement is concerned, we are talking about the virtual elimination of specific toxic contaminants. That means that they should be basically absent from the effluent, that means they should not be there, which implies that you should not find them, once, twice or three times, it doesn't matter how many times, just once." (p.401)

5. EFFECTIVENESS OF TREATMENT OF WATER AND SEWAGE CONTAINING NDMA

Evidence was heard on the chemical and biological degradation of NDMA in the natural environment and in water and sewage treatment facilities. In addition to the general chemistry of NDMA degradation, evidence was led about the degradation of NDMA in the treatment facilities on the Uniroyal Chemical Ltd. site in Elmira, in the Elmira STP, in the Grand River downstream of the Elmira STP and the proposed water treatment facilities of the Regional Municipality of Waterloo.

Dr. Meresz stated that:

"Once it (NDMA) is formed, it is not so easy to destroy but we have seen that the sewage treatment plant copes extremely well with NDMA when you look at the input and output. It's amazing what a good job it does... So, it seems to me that biological treatment is possible. NDMA can be destroyed by chemical means. There is literature on that. Whether it is feasible in this case, that has to be evaluated for each process that has been published, but ultraviolet light seems to destroy it, and again, it's not easy with an effluent because it's not a transparent, clear liquid and NDMA can probably be trapped in particulate matter. Anyway, that is a possibility, that ultraviolet irradiation will destroy it and even alternation (ozonation) can. In fact, ultraviolet often induces the same processes as ozone does...In the literature, there are indications it (ultraviolet irradiation) works and others report it doesn't, but that is no reason not to try it" (pp.1089-1090)

Dr. Lijinsky, commenting on the treatment and reduction of NDMA, stated that Dr. Gangolli from BIBRA had devised a method of reducing nitrosamines to amines using aluminium foil in a slightly acid solution which he found effective in destroying traces of nitrosamine in waste products. Dr. Lijinsky also suggested acidifying solutions of nitrosamine and letting them sit for a couple of days to hydrolyse the nitrosamine. He stated that ultraviolet light is also a well-known way of decomposing traces of nitrosamine but that it would be necessary to take measures to ensure the components of nitrosamine would not recombine. Dr. Lijinsky, expressing a reservation about ultraviolet irradiation of NDMA, pointed out that ultraviolet light does not penetrate very far into water. Dr. Lijinsky stated the treatment measures for NDMA, such as ultraviolet irradiation, would also be effective for other nitrosamines because the N-NO bond is attacked in the process. He suggested that the use of an oxidant to oxidize any amine present might prevent the reformation of the nitrosamine but that oxidation with peroxide might produce other carcinogenic byproducts. Dr. Lijinsky stated that aeration would not be an effective method of decomposing nitrosamines. He stated that he was not familiar with sewage treatment plants or their operation.

Mr. Thompson testified that he was not familiar with the engineering workings of the Elmira STP but the plant apparently treats NDMA quite effectively. Mr. Thompson elaborated that although the plant may achieve a high level of removal,

the evidence indicates that it has not been capable of reducing high influent NDMA levels down to the 0.5 µg/L level required by the MoE order.

Mr. Salbach, in reply when asked if he agreed that the Elmira STP effectively treats NDMA, stated, "No. I would not agree with that."(p.756)

He went on to say:

"I do not argue with you in any way that the sewage treatment plant is treating NDMA, there is no question about it, I agree with it and that is a given, but whether it can handle those loadings that are generated by these high concentrations at any significant interval from Uniroyal is, at the moment, doubtful and needs to be sorted out."(p.758)

Mr. Luhowy testified that he was Manager of Wastewater Operations for the Regional Municipality of Waterloo and Acting Director of the Division. Mr. Luhowy stated that the Region's By-Laws governing NDMA discharge to sanitary sewer systems were designed to avoid depending on the STP for much treatment of NDMA.

Dr. Pollock, Division Manager of CH2M Hill with responsibility for the firm's industrial wastewater treatment and hazardous waste treatment consulting activities, described the treatment program for NDMA wastewater submitted by Uniroyal Chemical Ltd. to the Regional Municipality of Waterloo. Commenting on the likelihood of success of this pilot treatment program, Dr. Pollock stated:

"With respect to treatment for NDMA, the technology that has been proposed by Uniroyal appears to be appropriate. However, I think the performance, reliability and so forth, cannot be judged at priority (a priori) and I think would need to be demonstrated with some reasonable period of time." (p.2201)

He expected that the proposed treatment plan would also be effective in the treatment of chemical constituents other than NDMA. Dr. Pollock stated that he understood there were particulate materials in the Uniroyal wastewater and that these materials could retard the efficiency of treatment; however, the particulate matter should be removed by a filtration process immediately upstream of the advanced oxidation process.

Dr. Lunn testified that of the various methods for treatment of NDMA in the literature, none had been clearly established as effective. He stated that he believed that the treatment method outlined in the Uniroyal Chemical Ltd. Compliance Plan could not meet the 0.5 µg/L NDMA objective but that it could come close. However, he acknowledged that he had not previously dealt with sewage treatment plants or industrial pretreatment plants and that he was not familiar with the operation of sewage treatment plants.

Mr. Ruck testified that as General Manager of Uniroyal Chemical Ltd., he is responsible for the entire Canadian company. He stated that the pre-treatment

facilities at Uniroyal are a large system and he explained that this treatment system relies on the Elmira STP to complete the treatment of Uniroyal wastewater.

Mr. Boose, Environmental Control Manager for Uniroyal Chemical Ltd. in Elmira, described the wastewater and rainwater collection and treatment systems at the Uniroyal site in Elmira. He also described the ultraviolet treatment system proposed for the Uniroyal site.

Dr. Frehner testified that he was employed by the consulting engineering firm of Conestoga-Rovers and Associates (CRA). CRA had been retained by Uniroyal Chemical Ltd. to:

- evaluate the treatability of NDMA in their wastewater;
- evaluate their existing wastewater treatment system and the Elmira STP;
- review NDMA treatment alternatives; and
- prepare a compliance plan.

Dr. Frehner stated that the Elmira STP is very effective in treating NDMA; however, CRA did not recommend biological treatment for NDMA at the Uniroyal site because they felt it could not achieve the required low levels of NDMA. Mr. Frehner reviewed the various NDMA treatment options considered by CRA and concluded that ultraviolet irradiation combined with oxidation by peroxide was the favoured alternative. He reviewed the results of a pilot treatment plant used to test this alternative. CRA performed tests on the reformation of NDMA after ultraviolet-oxidation treatment and found that no NDMA was reformed. Mr. Frehner stated that both the pilot and permanent ultraviolet oxidation systems at the Uniroyal site were to be located downstream from the activated carbon treatment and before the equalization tanks (exhibit 102).

6. NDMA CONCENTRATIONS IN THE GRAND RIVER SYSTEM

Sewage discharges from Uniroyal Chemical Ltd. and the Town of Elmira merge in the Elmira STP where they undergo treatment. The treated effluent is discharged into the Canagagigue Creek which is a tributary to the Grand River. Downstream, there are additional STP discharges to and several withdrawals for drinking water supplies from the Grand River. The first location of water withdrawal from the Grand River downstream of Canagagigue Creek is at Woolner Flats for the City of Kitchener water supply system. Water at this point is withdrawn from infiltration wells.

Mr. Salbach testified that an interim drinking water guideline for NDMA concentration of 0.014 µg/L in the Grand River water at Woolner Flats was adopted by the MoE. This level of concentration provided the basis for establishing the 0.5 µg/L NDMA concentration limit in the Elmira STP effluent. Mr. Salbach testified that these calculations were based on dilution modelling of the Grand River system and referenced calculations performed by Mr. R.C. Stewart (exhibit 9). Mr. Stewart had calculated that if the effluent from the STP contained NDMA at a concentration of 0.5 µg/L, by the time this same effluent reached the area of Woolner Flats the

NDMA concentration in the water of the Grand River would have diminished to a level of 0.014 µg/L.

Mr. Vickers testified that he has been a Water Resources Assessment Officer with the MoE in Hamilton since 1987. Mr. Vickers stated that he had conducted a number of stream assimilation assessments of the Grand River since January 1, 1990, and that he had calculated long-term acceptable levels of NDMA discharge to the Grand River system, as well as day-to-day concentrations based on Grand River flows. He testified that his calculations (exhibit 66) were made independently of Mr. Stewart's (exhibit 9) and included more recent information which had become available. Mr. Vickers described the MoE procedures for calculating discharge limits to streams which are based on worst-case conditions of drought flows. The drought flows used in these calculation are average weekly drought flows with a one-in-twenty year return period (7Q20 flow). Mr. Vickers stated that because of the flow regulation on the Grand River, the Grand River Conservation Authority can maintain a minimum discharge of 2.8 m³/s from the Shand Dam during the January to February 15 period and this flow rate was used in his calculations. Based on these assumptions, a discharge of 0.5 µg/L of NDMA in the Elmira STP effluent would result in a concentration of 0.014 µg/L of NDMA in the Grand River at Woolner Flats.

Mr. Zukovs testified that he was manager of the Toronto area office of CH2M Hill which was retained by the Regional Municipality of Waterloo to undertake an analysis of allowable concentrations of NDMA in the Elmira STP effluent. He outlined the data, assumptions and calculations used in the analysis (exhibit 76). He stated that a study of the literature led him to conclude that in-stream decay of NDMA in the Grand River during the winter period was insignificant, therefore, that decay was not included in his mass balance calculations. Mr. Zukovs provided calculations for the allowable NDMA concentration in the Elmira STP effluent based on 0 and 0.005 µg/L background concentrations of NDMA and for target NDMA concentrations of 0.014, 0.012, 0.010 and 0.007 µg/L in the Grand River at Woolner Flats. He noted that for a target NDMA concentration of 0.014 µg/L at Woolner Flats and assuming a background concentration of 0.005 µg/L, the calculated allowable NDMA concentration in the Elmira STP effluent was 0.5 µg/L.

Dr. McBean testified that he was a professor of Civil Engineering at the University of Waterloo and a technical advisor to Conestoga-Rovers and Associates. He told the Board he had been asked by CRA to: analyze streamflow records; to calculate allowable discharges to the Grand River system; and to review the analyses performed by Mr. Zukovs and Mr. Vickers. Dr. McBean stated that he used a methodology similar to that of Mr. Zukovs in his analysis (exhibit 110). He stated that he recognized seasonal variations in streamflows but that he excluded in-stream degradation of NDMA in his calculations. Dr. McBean indicated that his analysis incorporated recent data on NDMA concentrations which were not available to Mr. Zukovs at the time of Mr. Zukovs' analysis. He also indicated that he used a different approach to calculate averages for data with non-detectable concentrations reported (pp.4-5, exhibit 110; pp.3950-3951, transcript). Using his

parameter estimates and a water quality objective for NDMA concentration of 0.014 µg/L in the Grand River at Woolner Flats, Dr. McBean calculated allowable NDMA concentrations in the Elmira STP effluent as follows:

- 0.85 µg/L (January - February);
- 2.18 µg/L (May - October); and
- 1.46 µg/L (November - December).

Repeating these calculations for a water quality objective of 0.2056 µg/L NDMA at Woolner Flats, resulted in the following allowable NDMA concentrations in the Elmira STP effluent:

- 18.8 µg/L (January - February);
- 40.0 µg/L (May - October); and
- 28.6 µg/L (November - December).

Dr. McBean stated that in calculating the background NDMA concentrations of 0.00125 µg/L in the Grand River and Canagagigue Creek, he did not include the December 19, 1989 measurements of 0.012 and 0.015 µg/L, respectively, and that including these measurements would result in a lower allowable NDMA concentration in the Elmira STP effluent. Dr. McBean stated that the December 19, 1989, measurements of 12 and 15 µg/L of NDMA in the Grand River and Canagagigue Creek were excluded because he had suspicions about their reliability. Dr. McBean agreed that the utilization of seasonal streamflows in determining allowable STP discharges involves a degree of judgment.

7. GROUNDS OF THE APPEAL(S)

At the end of this lengthy Hearing, Mr. Millar, counsel for Uniroyal, acknowledged that many of the individual issues in Uniroyal's appeals to the Director's Emergency Direction and Notices, and Uniroyal's Consolidated Grounds of Appeal (exhibit 11) had been resolved during the course of the Hearing.

In written argument submitted on behalf of Uniroyal Chemical Limited, Mr. Millar stated that in general the issues that were outstanding at the end of the hearing were as follows:

- "a) the Director had no jurisdiction to issue the Emergency Direction and Notices under the Emergency Direction;
- b) there was no emergency, therefore the Director erred in issuing an Emergency Direction;
- c) what concentration of NDMA can be permitted in the effluent of the Elmira STP so that the concentration in the Grand River at Woolner Flats will not present an unacceptable risk to people consuming water from the Kitchener-Waterloo water distribution system taken, in part, from the Grand River through the infiltration wells at Woolner Flats;

- d) the sampling and analytical protocols used by the Director are inappropriate, not validated and unreliable; and
- e) the Notices to cease discharges to the Elmira STP were improper since there were inaccurate test results."

Mr. Garrod, in argument, took the position that the Board should make factual findings on the issues that are before it whether or not the Board felt it had jurisdiction. He stated that it would be valuable to have the Board's factual findings and whatever Order the Board considers appropriate. Mr. Millar agreed with Mr. Garrod's position.

The Board will not repeat in this Decision the lengthy argument submitted by counsel for the parties respecting each of the issues as they are a part of the record. Rather, the Board will set out hereafter its opinion on these many issues.

FINDINGS:

In spite of the many days of testimony heard from the many very distinguished, eminent and credible witnesses, there were issues on which the Board felt it had insufficient evidence to draw definitive conclusions. This is not necessarily a reflection on the ability of the witnesses, or of counsel, but rather a reflection of the state of information and knowledge on many of the issues. Among the most debated of the issues were:

- the appropriate guideline or standard for NDMA concentration in drinking water;
- the reliability of methods of chemical analysis for NDMA in water and sewage samples; and
- the appropriateness of the degree of urgency expressed in the Emergency Direction issued by the Director, Hamilton Regional Office of the MoE on Uniroyal Chemical Ltd.

The ideal result of the judicial process is to draw succinct and definitive conclusions from the evidence on an issue-by-issue basis which would then lead to a final conclusion of findings. In this Hearing, this was not always possible. The following discussion of findings attempts to draw conclusions on a issue-by-issue basis to the extent possible and indicates where the Board feels insufficient evidence exists to draw definitive conclusions. This discussion is followed by a more general synthesis of evidence across the many issues.

At this point, it is appropriate to make a general statement about the constitution, prerogative and principles of the Environmental Appeal Board. The Board is provided for by the Ontario Water Resources Act and The Environmental Protection Act of the Province of Ontario. Its purpose is to review decisions of MoE

Directors under the provision of these Acts, the major provisions of which are the protection of the natural environmental and the public health. The Board is therefore guided by the principle that the natural environment and the public health must be protected, and the more uncertain the evidence is, the more conservative in drawing conclusions the Board must be in favour of environmental protection and public health.

1. DETERMINATION OF ALLOWABLE NDMA CONCENTRATION IN DRINKING WATER

1.1 Risk Level

The Board accepts the evidence of many witnesses that zero discharge of contaminants to the waterways of the Province of Ontario should be the ultimate long-term goal. However, in the short-term, some discharges may be necessary but those which pose a significant threat to human health cannot be allowed. Therefore, the Board accepts that the risk of carcinoma from NDMA in drinking water should not exceed an excess cancer rate of one in one million (a 10^{-6} risk level).

1.2 Toxicological Assessment

1.2.1 Epidemiological data:

The Board finds that the most suitable epidemiological data on which to base a toxicological assessment of NDMA in drinking water is the data set produced by Brantom for BIBRA (Brantom et al, 1978; Brantom, 1983).

1.2.2 Pathological endpoint

The Board accepts that the most sensitive pathological endpoint of NDMA in drinking water is carcinoma.

1.2.3 Tumour types

The Board, because of the disparity of opinion, finds it necessary to base its conclusion on the selection of tumour types which leads to a sufficiently conservative slope factor rather than on the basis of preferring one of the several conflicting opinions of credible toxicological experts. Bearing in mind that the data of the Brantom study is from tumour incidence in rats which must be extrapolated to the human population, the Board finds that the inclusion of all these tumours

provides for a more conservative slope factor than the inclusion of only selected tumour types. However, the Board finds that including hyperplastic nodules, which the evidence shows not to be carcinomas, is overly conservative and unnecessary.

1.2.4 Risk-dose model and slope factor

Three major approaches were advocated in the testimony:

- the Weibull time-to-tumour model;
- the linear multi-stage (LMS) model; and
- the model-free extrapolation (MFX) method.

Evidence was heard that the model-free extrapolation (MFX) method was an "in-house" Health and Welfare Canada (HWC) model that had not yet benefited from peer review outside of HWC. The Board finds that without further evidence to substantiate this method, it cannot accept the MFX method for the purpose of this Decision. Compelling evidence was heard for utilizing both the Weibull and LMS models. The Board finds that it must accept the risk-dose model which produces the more conservative slope factor which, with the other conditions accepted in this case, is the LMS model. In making this finding, the Board is, however, influenced by the testimony of Dr. Nestmann that the LMS model is based on the physiology of carcinoma and by the testimony of Ms Meek that time-to-tumour data is determined in an approximate manner.

1.2.5 Dose scaling

The Board finds from the evidence that there is sufficient uncertainty in the mechanisms of human carcinogenesis with respect to NDMA in drinking water that it is prudent to apply the body surface area correction factor to calculations based on epidemiological studies of rats. The Board accepts that the normal expected lifespan of rats in epidemiological studies of carcinogenesis in rats is 2 years.

1.2.6 Per capita drinking water consumption

The Board finds that, in combination with the other conservative factors employed for the toxicological assessment of NDMA in drinking water, the average rate of drinking water consumption in Canada reported as approximately 1.5 litres per capita per day is sufficiently conservative for the assessment. This is the rate that has been adopted by HWC and consequently used in their calculations. The Board finds that while a rate of 2.0 litres per capita per day may be exceeded by some individuals at some times in their lives, the national average drinking water consumption over a lifetime is appropriate to use, especially when the Board has attempted to find in favour of a conservative approach on many other factors that collectively impact upon the risk.

1.2.7 Average vs. more sensitive group of the population

The Board accepts that subsets of the population may be more sensitive to NDMA exposure in drinking water than the average of the population; however, the Board recognizes that the epidemiological data available reflect lifetime exposures. The Board also accepts the testimony of Ms Meek that there should be sufficient conservatism in the toxicological assessments to be protective of the more sensitive individuals in the population. Therefore, the Board finds that the lifetime exposure epidemiological data is appropriate for the toxicological assessment in combination with other conservative factors used in the assessment. The Board also finds that when epidemiological data is available on the basis of sex, as it is in the Brantom study, it is appropriate to use the tumour incidence data for the more sensitive sex.

1.2.8 Synergistic effects

The Board finds that there is insufficient evidence to account for synergy between NDMA and other chemical constituents in drinking water in a quantitative toxicological assessment of NDMA and that it is beyond the capability of contemporary science to incorporate such synergistic effects in this assessment.

1.3. Alternative NDMA Exposure Pathways

The Board acknowledges the existence of alternative NDMA exposure pathways by virtue of occupation, lifestyle and individual physiology. However, the Board is persuaded that it is appropriate to conduct a toxicological assessment of NDMA in drinking water at a risk level of 10^{-6} independently of these alternative pathways.

1.4 Action Limits vs. Fixed Standards

The Board accepts the testimony of Ms Vajdic that the interim drinking water quality guideline for NDMA of 14 ppt associated with a risk level of 10^{-5} was an action limit for the short-term set by the MoE. The Board finds that the action limit was appropriate for the emergency direction issued at the time but that a more stringent limit is required for lifetime exposure.

1.5 Drinking Water Standards for NDMA

The Environmental Appeal Board is not empowered to devise broad Provincial policy regarding drinking water quality standards. The Board does not have research staff or research facilities. The composition of the Board is not designed to reflect expertise in all areas of the physical, health and social sciences and the humanities. Hopefully, the Board reflects public values and attitudes in some reasonable balance and has the ability to bring some degree of rationality and common sense to a judgement of findings. However, the Board's findings can only be as good as the evidence brought before it, and this evidence is heard on a case-by-case basis. Therefore, findings of the Board regarding appropriate drinking water standards for NDMA are specific to the evidence adduced in this Hearing which is the only evidence available to the Board. Clearly, other evidence available to other authorities, at this time or at some future time, could lead to other findings, other conclusions, and other recommendations.

Based on the evidence brought before the Board on the magnitudes and uncertainties associated with the various aspects of both the toxicological assessments and chemical analysis for NDMA, the Board finds that there is an insufficient basis to accept a drinking water quality standard for NDMA specified at more than one significant figure of magnitude. To one order of magnitude, the drinking water standards for NDMA concentration found in the evidence range from 10^{-5} to 10^{-1} $\mu\text{g/L}$ (ppb). The determination based on the Brantom data at the 10^{-6} risk level, excluding that of HWC using the MFX method, range from 10^{-3} to 10^{-2} $\mu\text{g/L}$ (ppb) in order of magnitude. Adopting the findings of the Board respecting the various aspects of toxicological assessment of NDMA, the resulting order of magnitude of the drinking water standard for NDMA concentration is in the range of 0.001 to 0.010 $\mu\text{g/L}$ (ppb). From the evidence adduced, the detection limit for NDMA analysis decreased considerably during the course of the Hearing. By the end of the Hearing the analysis results consistently reported for actual samples was found to be 0.010 $\mu\text{g/L}$ by GC/HRMS although, in some instances, analysis results were reported at a detection limit of 0.005 $\mu\text{g/L}$.

Therefore, based on the evidence available to the Board in this Hearing, the Board finds that the maximum level of NDMA in drinking water supplies should not exceed the 0.010 $\mu\text{g/L}$ detection limit (i.e., be nondetectable at 0.010 $\mu\text{g/L}$). As detection and remediation technologies improve, this limit should be correspondingly lowered.

2. QUANTITATIVE CHEMICAL ANALYSIS FOR NDMA

The Board accepts that before an analytical procedure for quantitative chemical analysis can be recommended, it must be verified through interlaboratory comparisons and subjected to quality assurance/quality control programs. The evidence revealed that the three round-robin interlaboratory studies produced highly divergent results. From the comparative data available to the Board through

the three round-robins conducted and through other evidence presented on NDMA analysis, the Board finds that the GC/HRMS is the most reliable method of analysis for NDMA in water and sewage samples at the present time. The Board also acknowledges that the evidence from the results of the three round-robin interlaboratory studies shows the GC/LRMS method to be reliable for particular samples analyzed by particular laboratories. The Board accepts that the detection limit of the MoE GC/HRMS laboratory for NDMA analysis in sewage and "dirty water" samples is at least 0.010 µg/L (ppb) based on evidence brought forward during the course of this hearing.

The Board finds that Dr. Lijinsky's evidence - given before the three round-robin interlaboratory studies were conducted - wherein he supported the TEA method, was not verified by the round-robin results.

The Board finds that at the time of the December 30, 1989 Emergency Direction and the January 18, 1990 and February 2, 1990 Notices to discontinue discharge, the reliability of the MoE sampling and analysis procedures for NDMA was not well-quantified. However, the Board finds that this was the best data available at the time. This data indicated significantly high concentrations of NDMA and this provided sufficient grounds for the Director to take action.

The Board finds that at the time the Emergency Direction and Notices were issued, the MoE had never established any criteria or procedure for approving laboratories to perform chemical analyses such as were required of Uniroyal under this order.

3. CHEMICALS OTHER THAN NDMA

The Board finds that with the exception of the testimony of Dr. Lunn, there was concurrence in the appropriateness of the effluent parameter scan proposed in Appendix E of exhibit 102 and included in this Decision as Appendix H. The Board accepts that this list of parameters should be monitored in the discharge of Uniroyal Chemical Ltd. to the Elmira STP.

4. COMPLIANCE MECHANISM

The Board accepts that the enforcement of the Emergency Control Order should be based on sample averages with a single sample upset limit rather than on the result of one single sample for the determination of NDMA concentration.

5. TREATMENT FOR NDMA

The Board accepts that the Elmira STP has a general ability to degradate NDMA in its processes but that the removal efficiency is not accurately quantified. Therefore, the Elmira STP cannot be relied upon to treat NDMA so as to produce an effluent

concentration less than 1 ppb regardless of the level of NDMA in the influent to the STP.

The Board accepts that the NDMA treatment methods proposed by Uniroyal Chemical Ltd. in the Interim Wastewater Treatment/Compliance Plan (exhibit 102) comprise a state-of-the-art approach to NDMA treatment.

6. NDMA CONCENTRATION IN THE GRAND RIVER

The Board finds that the allowable discharge of NDMA from the Elmira STP should be based on the worst case streamflow in the Grand River (low flows in the January-February period of the year) to provide for additional protection of the public health and for realistic surveillance and enforcement programs. For this streamflow condition, the Board finds that the methodologies of Mr. Vickers, Mr. Zukovs and Dr. McBean are quite similar. Mr. Zukovs provided calculations based on background concentrations of 0 and 0.005 µg/L while Dr. McBean based his calculations on a background concentration of 0.00125 µg/L. Adopting the 0.010 µg/L concentration of NDMA in the Grand River at Woolner Flats, Mr. Zukovs' calculations of the allowable concentration of NDMA in Elmira STP effluent are 0.5 and 0.1 µg/L at the background concentrations of 0 and 5 µg/L, respectively. Dr. McBean's treatment of non-detectable measurements allowed for relatively higher discharges of NDMA from the Elmira STP.

The Board finds an irony in this methodology inasmuch as the lower the discharges from other sources, the higher the allowable discharges from the Elmira STP. In other words, the more other sources of NDMA contamination of the Grand River system are eliminated, the less the mitigation required in the Elmira STP discharge. It is the sense of the Board that all sources of NDMA discharged to the Grand River system should be identified and mitigated. As one source declines, other sources should also decline rather than be allowed to escalate. For this reason, the Board finds that the level of NDMA discharge from the Elmira STP should not exceed 0.2 µg/L. With historical discharges of NDMA from all sources including the Elmira STP to the Grand River system, this would result in a concentration of NDMA not exceeding 0.010 µg/L at Woolner Flats. As mitigation of NDMA from other sources into the Grand River takes place, this concentration at Woolner Flats would be correspondingly decreased.

7. GROUNDS OF APPEAL

In an effort to ensure clarity of its opinion, the Board sets out hereafter, its opinion on each of the issues raised in the Grounds of Appeal by the appellant. Some of the following points will be repetitious for they have been dealt with earlier from the Findings regarding the technical issues. However, the Board feels it is important that its opinion be stated in one section to render a clear understanding

of the Board's position. For ease of reference, the headings and numbering correspond to those within the Consolidated Grounds of Appeal (exhibit 11).

I. GENERAL GROUNDS

1. The Board does not find the discharge requirements that were set out in paragraphs 4 & 8 of the Emergency Direction are arbitrary, unreasonable or unjustifiable on an environmental or technological basis. These discharge requirements of 10.0 µg/L in the wastewater discharge from Uniroyal to the Elmira STP and 0.05 µg/L in the effluent from the Elmira STP to the Canagagigue Creek are reasonable and justifiable on environmental grounds and, by Mr. Ruck's testimony, attainable levels.
2. The Board does not consider the permissible levels of NDMA specified in paragraphs 4 & 8 of the Emergency Direction to be unduly low when one has regard to the levels of NDMA in edible foods and beverages. While the evidence indicated that there is no question there are instances of high levels of NDMA in edible foods and beverages and tobacco smoke, the evidence is that this is undesirable, and the Board finds that the evidence presented indicates that the best course would be to reduce the levels of NDMA in municipal drinking water supplies to as low a level as possible. There is proof that NDMA is known to be an animal carcinogen and considered to be a potential human carcinogen, thus every effort should be made to reduce any potential toxicity to humans from drinking water.

It is not within the ambit of this Hearing to determine what levels of NDMA should be permitted in food, beverages, tobacco smoke, etc. These are not issues before the Board at this time, in this matter.

3. & 4. The Board finds that at the time of the Emergency Direction, the MoE's analytical testing and sampling methods and protocols required more refinement. However, these methods and protocols were the ones available at the time, and it would have been negligent of the MoE not to have acted on this information. The need to improve these methods was apparent to all parties and after some prodding the MoE took steps to improve these methods. The Board finds that it would have been improper for the Director to delay action until every improvement to the methods was made.
5. The Board finds that the accuracy of the various analyses for NDMA in the Elmira STP effluent upon which the Director based his Notices and Orders were not well quantified and hence uncertain. The Board finds that the evidence led indicates that it would have been virtually impossible to accurately define the exact levels of NDMA in the effluent tested in December 1989 and January and February 1990 with the equipment and experience available at the time. However, the Board finds that the levels were significantly elevated and the Director was right to assert that these levels could pose a threat to the drinking water supply for the citizens of the Region.

6. The Board finds that at the time the Emergency Direction was issued, both the Uniroyal and the MoE laboratories were unable to comply with the requirement that the samples be tested and results reported within 72 hours of the time the samples were taken. The Board finds that the laboratories for Uniroyal and the Ministry of the Environment are now capable of producing test results within a 72 hour turn-around time.
7. Quality assurance/quality control protocols for the sampling and analysis of NDMA were developed during the course of this Hearing and at the same time scientific instrumentation has developed to the point where low detection levels are now possible. It is now feasible to complete the analyses required by the Emergency Direction in the allotted time.
8. With respect to the requirement in Part III, paragraph 3, of the Emergency Direction (wherein Uniroyal is required to sample and analyse for NDMA, its discharge to the Elmira STP and also at the inlet to the Uniroyal Chemical aeration tank, for NDMA three times weekly), during the course of this Hearing this objection has been dealt with through discussions between Uniroyal and the Ministry of the Environment.
9. The Board does not accept Uniroyal's contention that the level of discharge of NDMA into the Elmira STP and the level of discharge of NDMA from the Elmira STP to the Canagagigue Creek poses no danger to the health or safety of any person, and does not impair or create an immediate risk of impairment of any waters, and has not caused injury and damage or the immediate risk of injury or damage to any property or to any plant or animal life. The Board finds that there is significant evidence that NDMA poses a potential danger to human health.

The Board finds that "impairment" of the water is possible if any level of NDMA is present. The Board finds that impairment can be interpreted as damage and there is no doubt among the Board members sitting this Hearing that the evidence definitely indicates that any level of NDMA present in the water poses a level of danger and while it may appear insignificant it cannot be disregarded.

10. The Board accepts that the impact of the Emergency Direction and Notices/Orders dated January 18, 1990, January 26, 1990 and February 2, 1990, were not disproportional to the problems or perceived problem which the Direction issued by the Director sought to remedy.
11. This Hearing has provided an opportunity for Uniroyal to present its case before the Environmental Appeal Board. Further, the Board finds that all other parties have also had ample opportunity to present their viewpoints on the Director's action.

Although the Direction/Notices/Orders and this Hearing process impacted the operations of the Uniroyal facility, such impact was justified by the detection of significant levels of a suspected potent human carcinogen.

12. The Board is of the opinion that Uniroyal has indicated a willingness to work with the Ministry of the Environment to remedy the problem of impairment of its effluent to the Elmira STP by the presence of NDMA. Nevertheless, the Board finds that it is appropriate for the Director to set down in an Order his conditions and requirements respecting Uniroyal's future responsibilities and actions to remedy this serious problem.

II JURISDICTIONAL GROUNDS

13. The Board finds that the Director did have jurisdiction to make the Emergency Direction dated December 30, 1989 as, Mr. Salbach testified, he believed that the test results given to him showing high levels of NDMA in the Elmira STP effluent and the Uniroyal effluent and, based on these figures, he deemed this to constitute an emergency. Mr. Salbach acted in a hasty manner and the Board finds that Mr. Salbach might have been wiser to have followed the procedure and issuing a Notice of Intention to issue an Order followed by the issuance of an Order. The Board finds that Mr. Salbach's assessment of the conditions existing on December 29 and 30, 1989 constituted an emergency and Mr. Salbach, in his capacity as Acting Director, did have jurisdiction to take action and issue an Order.
14. The Board finds that the issue as to whether or not the Director was properly appointed is an issue that should be decided in another forum. Whether the Minister and/or the Minister's subordinates erred in not ensuring that Mr. Salbach was properly appointed as a Director is not, in the Board's opinion, a real issue in this Hearing. There is no dispute that Mr. Salbach was appointed as Acting Director and, in the Board's view, he was responsible for discharging the responsibilities of the Director's position.

In the Board's opinion there should be a review by the Minister of the Environment of the wordings in the Environmental Protection Act and the Ontario Water Resources Act respecting the appointment and responsibilities of the Director.

15. The Board finds that in its opinion, section 17(1) of the Ontario Water Resources Act does permit the Director to regulate the discharge of sewage into a river or stream. The Board finds that the Director is responsible for upholding the Environmental Protection Act and the Ontario Water Resources Act - both Acts which are designed to preserve the natural environment. Thus, the Director does have the authority to set standards on a case-by-case basis that will modify any discharge into a river or stream, either directly or indirectly.

16. Respecting section 44(1)(f) and (h) of the Ontario Water Resources Act - the Board finds that this section appears to be in conflict with sections 2, 4, 13 and 16 of the Environmental Protection Act. The Board interprets the intent of both acts to empower the Director to take such steps as may be necessary - within the rules and regulations as set out in the Acts and their respective regulations - to preserve and protect the natural environment. The Board heard evidence that municipalities may adopt bylaws to regulate the content of influent to their sewage treatment plants. The Board finds the claim puzzling that only the Lieutenant Governor in Council may make regulations similar to those that may be enacted by a local municipality but that a Regional Director of the MoE may be denied the authority to develop and apply regulations to control local emissions on a site-specific basis. The Board finds that the Director must have the authority to set standards on a case-by-case basis that will modify any discharge into the natural environment, either directly or indirectly.

The Board urges the Minister of the Environment to consider amendments to the wordings in section 44 of the Ontario Water Resources Act in light of the Director's responsibilities as set out in the Environmental Protection Act to ensure a common-sense understanding of the similar intent of these Acts..

DECISION:

Pursuant to its powers under the Environmental Protection Act and the Ontario Water Resources Act, the Environmental Appeal Board hereby confirms the actions of the Director in issuing against Uniroyal Chemical Ltd., an Emergency Direction dated December 30, 1989 and subsequently, the Director's Notices dated January 18, January 26 and February 2, 1990.

The Board recognizes that the evidence presented at the Hearing in this matter has afforded all parties a greater understanding of the chemical N-nitrosodimethylamine. As a result, the Board finds that the intent of the action of the Director would be better served by issuing a new Order to Uniroyal. This new order does contain some directions made by the Board to the Director.

Section 123 (1) of the Environmental Protection Act states that the Board ". . . may confirm, alter or revoke the action of the Director . . . and may by order direct the Director to take such action as the Board considers the Director should take . . . and . . the Board may substitute its opinion for that of the Director." It is the decision of the Board that a new Order should be issued.

The Board recognizes that the operation of the Elmira STP does not fall within the direct jurisdiction of the Director. Nevertheless, the effectiveness of this Order issued against Uniroyal requires the co-operation of the Region, which owns the STP, and the branch of the MoE responsible for operating the STP on behalf of the

Region. Without their assistance and co-operation the implementation of the following Order of the Board will be less than satisfactory.

ORDER:

1. Discharges from the Elmira Sewage Treatment Plant:

The Board recommends that the final discharge from the Elmira Sewage Treatment Plant (STP) must not exceed 0.2 µg/L N-nitrosodimethylamine (NDMA). In order to ensure that accurate monitoring is achieved, a running average of 5 analytical results will determine the level of NDMA. If a sample of the Elmira STP effluent when analyzed yields a concentration above 0.4 µg/L of NDMA, or when averaged with the previous 4 results, confirms concentrations greater than 0.2 µg/L of NDMA and Uniroyal is deemed a source of that NDMA, the Director, or his designate, will immediately notify Uniroyal. Upon receipt of such notice, Uniroyal will immediately discontinue any discharges to the STP.

2. Uniroyal's Wastewater Discharges to the Elmira STP:

The concentration of NDMA in any discharge of wastewater from Uniroyal to the Elmira STP shall not exceed 0.2 µg/L.

2.1 Batch Discharges:

Uniroyal Chemical Ltd.'s discharge of wastewater to the Elmira STP shall be by means of batch discharge unless as otherwise allowed in this Order. In order to verify compliance with the discharge limits, batch discharges will be sampled and analyzed by Uniroyal. All wastewater must be treated in batches and held in storage pending verification. Representative samples of treated water will be collected and analyzed for NDMA content following the procedures for collection and testing of samples. Split samples will be made available to the Ministry of Environment upon request. If the sample results are verified to be equal to or less than 0.2 µg/L NDMA, the batch wastewater may be discharged. If the level of NDMA in the wastewater batch exceeds 0.2 µg/L, the wastewater must be retreated and the verification procedure must be repeated.

In the event that a batch is discharged over a period of a week or more, Uniroyal shall sample and analyze for NDMA in its discharge of wastewater to the Elmira STP using a composite sample once each week that such batch discharge continues.

2.2 Continuous Discharge:

When Uniroyal can demonstrate that the average concentration of NDMA in a minimum of ten consecutive batches of wastewater does not exceed 0.2 µg/L to the STP, Uniroyal may request the Director to approve continuous discharge of its wastewater. If the Director is of the opinion that Uniroyal's continuous discharge will meet the discharge limits of 0.2 µg/L for NDMA, he shall give notice to Uniroyal that continuous discharge is permitted. Refusal by the Director to allow continuous discharge in the foregoing circumstances shall be deemed to be an Order of the Director and Uniroyal may request a hearing by the Environmental Appeal Board with respect to such an Order.

When Uniroyal is permitted to continuously discharge its wastewater to the Elmira STP, it must take and test a sample of the effluent at intervals no greater than once every 400,000 litres. The level of NDMA in any such samples taken from this continuous discharge must not exceed 0.2 µg/L except as hereinafter stated.

Where any one sample from the continuous discharge, when analyzed, shows the NDMA concentration to exceed 0.2 µg/L, Uniroyal must immediately take a second sample.

Should this second sample, when analyzed, show the NDMA concentration to exceed 0.4 µg/L, Uniroyal must immediately cease any further discharge to the Elmira STP. Discharge to the Elmira STP may not be restarted, except by batch discharge and only when the batch has been retested and proven to have a concentration of NDMA less than 0.2 µg/L.

2.2.1 Elevated NDMA Levels in the Continuous Discharge:

If any one sample taken during continuous discharge, when analyzed, indicates an NDMA concentration greater than 0.2 µg/L and less than 0.4 µg/L, Uniroyal shall immediately take another sample and test same.

If this second sample yields results less than 0.4 µg/L of NDMA, Uniroyal may continue its continuous discharge to the Elmira STP. However, it must immediately commence taking samples so that each 200,000 litre volume of effluent is tested. Sampling must continue at this frequency until such time as the results indicate a concentration of NDMA less than 0.2 µg/L.

Should any five consecutive samples taken indicate an average concentration of NDMA greater than 0.2 µg/L, Uniroyal shall immediately discontinue its discharge to the Elmira STP. Discharge to the Elmira STP may not be restarted except as outlined in paragraph 2.1 of this Order.

3. Treatment of Uniroyal Wastewater:

Uniroyal shall treat all of its wastewater with the ultraviolet/hydrogen peroxide treatment system, or such other treatment system that it may develop and install which will effectively reduce the levels of NDMA in its wastewater to a maximum level not exceeding 0.2 µg/L, prior to the discharge of any such wastewater to Elmira STP.

4. Uniroyal Discharge Testing and Reporting of the Results:

Uniroyal shall provide the results of the analysis of its discharges of wastewater to the Elmira STP to the Ministry of the Environment and shall be bound by the results reported. Uniroyal shall communicate the results of its analysis to the Ministry of Environment by FAX within three hours of determining the analysis results and, in all cases, no later than 72 working hours after the sample has been taken.

4.1 Sampling and Analysis Protocols:

Sampling and analysis shall be done in accordance with the sampling and analytical protocols outlined in Appendices A and B of this Order, or such other protocols which may, in future, be developed and approved by the MoE.

4.2 Sampling Personnel:

Sampling of Uniroyal's discharge of wastewater to the Elmira STP shall be performed by Uniroyal.

4.3 Analysis Methodology:

Analysis of the Uniroyal discharge of wastewater to the Elmira STP shall be performed by the Uniroyal Chemical Ltd. Guelph laboratory using the GC/LRMS method or the Uniroyal Chemical Inc. Connecticut laboratory using GC/LRMS or GC/HRMS methods, or at any other laboratory approved by the Director, Ministry of Environment.

4.4 Split Samples:

Upon request from the staff of the Ministry of the Environment, Uniroyal will provide split samples of any discharge to the Elmira STP.

5. Uniroyal In-House Analytical Capability:

Uniroyal shall maintain, and where necessary enhance, its 'in-house' analytical capabilities to measure NDMA for the purpose of this Order, unless Uniroyal arranges for another laboratory acceptable to the Director to perform the analyses required by this Order.

Should the Director refuse to approve another laboratory, which meets the criteria set out in Item #6 below, within thirty days of receipt of written request by Uniroyal, Uniroyal may appeal such refusal to the Environmental Appeal Board.

6. Approval of Laboratories by the MoE:

Within 180 days of the date of this Order, the Director shall document and distribute the criteria and procedures for the approval of laboratories to perform the analyses required by this Order.

7. MISA Location Monitoring:

Uniroyal shall sample and analyze the MISA control points 0100, 0200, 0400, 0600, 0800, and 0900 on a monthly basis for NDMA and other substances listed on the effluent parameter scan list (Appendix H) if any flow occurs during the month.

8. Monitoring of the Elmira STP:

The Board recommends that sampling and analysis of the Elmira STP effluent shall be performed at least once a month. All sampling should follow the sampling protocol for NDMA included in Appendix A, and analysis should follow the analytical protocol for NDMA outlined in Appendix B.

8.1 Sampling Personnel:

The Board recommends that personnel to undertake the sampling at the Elmira STP be designated by the Director.

8.2 Analytical Personnel:

The Board recommends that the Ministry of Environment (MoE) laboratory in Rexdale, Ontario should analyze the samples from the

Elmira STP. The Director may designate another laboratory to perform the analysis provided that laboratory, in the Director's opinion, can perform the analysis in accordance with the analytical protocol outlined in Appendix B of this Order.

8.3 Samples:

The Board recommends that upon request by Uniroyal or the Regional Municipality of Waterloo, the MoE shall provide split samples of the effluent samples obtained from the Elmira STP.

8.4 Elevated Levels of NDMA in the Elmira STP Effluent:

The Board recommends that where any one sample, when analyzed, yields a concentration of NDMA greater than 0.4 µg/L, the MoE will immediately notify Uniroyal and take a second sample within 24 hours, and daily thereafter, until the concentration of NDMA in the STP effluent drops to an average of 0.2 µg/L.

8.5 Determining whether Uniroyal is a source of NDMA concentration:

The Board recommends that where a sample of the final effluent from the Elmira STP is analyzed and the result obtained is greater than 0.4 µg/L NDMA, the MoE commence sampling the discharges from the Municipal and Industrial sections of the Elmira STP contemporaneously with any sampling of the final effluent of the Elmira STP until such time as the average of 5 consecutive samples of the final effluent falls below 0.2 µg/L NDMA.

Uniroyal shall be deemed the source of the NDMA in the Elmira STP discharge if the average concentration of NDMA in the sewage from the Industrial section entering the Sewage Treatment Plant is greater than the average concentration in the sewage from the Municipal section entering the plant.

9. Sampling of the Grand River:

The Board recommends that the MoE sample and analyze the water in the Grand River at Woolner Flats at least once a month. In the event that the discharge from the Elmira STP is greater than 0.2 µg/L of NDMA, sampling should be conducted weekly until such time as the level in the Elmira STP effluent drops to 0.2 µg/L NDMA or lower - based on the average of 5 consecutive samples.

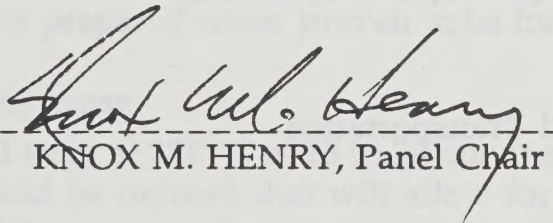
10. Turn-around Time:

Results of the analysis of all samples required under this Order must be reported within three working days [72 hours] of the time of taking the sample. Saturdays, Sundays and statutory holidays are not considered working days.

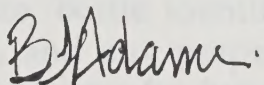
11. Access to the Premises:

Uniroyal shall allow access to the Uniroyal site in Elmira to the Ministry of the Environment staff upon request, and provide a person who is capable of showing that Ministry of Environment staff member any and all aspects of the operation which would relate to the potential sources of NDMA and Uniroyal's wastewater treatment systems.

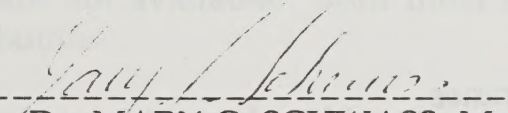
12. This Order does not permit Uniroyal to contravene any federal, provincial or municipal law.



KNOX M. HENRY, Panel Chair



PROF. BARRY J. ADAMS, Member



Dr. MARY C. SCHWASS, Member

DATE: February 4, 1992

SAMPLING PROTOCOL FOR NDMA

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1.1 Sample Containers and Pretreatment

1.1.1 Sample Bottle Preparation

Sample bottles are to be prepared in the laboratory, by trained laboratory personnel only, and then distributed to field/sampling staff. The procedures for sample bottles are as follows:

- (i) New one litre, wide mouth, amber (preferred) or clear glass bottles. Note: Clear glass bottles should be wrapped in aluminum foil

- (ii) Cleaning Procedure

New (unused) bottles need not be cleaned providing they have not been previously opened. "Previously used" bottles may be used providing they are labelled accordingly and cleaned as follows. (The full bottle washing procedure must be repeated twice):

- a) Hot soapy water wash
 - b) Tap water rinse
 - c) Distilled water or prepared water proven to be free of NDMA
 - d) Acetone rinse
 - e) Dichloromethane rinse
 - f) Oven dried for 1 hour at 121° C or 15 to 30 minutes at 400° C
 - g) A schedule should be defined that will allow for sufficient cooling of bottles followed by capping the same day in a controlled environment
 - h) A record of the date, bottle identification number, initials of bottle preparation person, and any preparation problems concerning each lot of bottles should be kept for future reference
 - i) Acetone rinse of teflon cap (preferably) or teflon film
- (iii) The bottle cap liner must be teflon. The use of teflon film is allowed only if teflon lined caps are not available. Both must be rinsed with acetone prior to capping the bottle.
 - (iv) QA/QC: A bottle blank must be analyzed by the organics department. One blank for every 50 bottles (see the Analytical Protocol [Appendix B] for this procedure).

1.1.2 Labels

All bottles must have a label affixed that indicates the laboratory of origin. The following information must be clearly shown (at a minimum):

- (i) The bottle identification code
- (ii) The sampling date and time

- (iii) The name or initials of the sampler
- (iv) The sample identification or code
- (v) Indication of the presence of residual chlorine

1.2 Sampling Protocol

The sampling protocol establishes a standard procedure for collection of samples to eliminate variations in results caused by sampling differences. To address this sample objective, samples must be collected by trained personnel only, using the established protocols.

1.2.1 General

(i) Sampling Environment

The person(s) at each location will refrain from cooking, smoking and burning (i.e. wood burning stoves, fire places, cigarettes, etc.) immediately prior to (i.e. minimum 15 minutes) and during sample collection. Any events which may potentially affect sample integrity must be noted in the sampler's log book, including any vehicle exhaust or other upwind contributors.

(ii) Gloves

PVC gloves should be used by sampling personnel. As a component of good sampling protocol, care must be taken that gloves or hands do not come in contact with the inner surface of the cap, the teflon film, or the neck of the bottle.

Caps/film should be placed with the sample contact surface facing up while sampling.

(iii) Headspace

Bottles must be filled fully to provide a positive meniscus in order to minimize headspace upon capping.

1.2.2 Sample Collection

(i) General

- a) The wide mouth of the bottle may be used as a scoop.
- b) Stainless steel utensils may be used, wiped clean and rinsed with organic-free water and acetone, between each sample collected.
- c) After capping, the outside of the bottle must be rinsed with distilled water and wiped clean to minimize the potential of cross contamination during shipment to the laboratory in the cooler.

d) Apply a sampling label.

Note: The sample container must not be rinsed with the sample liquid and the neck of the bottle must not come into contact with the gloves or any other foreign material.

- (ii) Large volume water samples where containers cannot be located directly in sampling stream:

Teflon tubing may be used for sample transfer if it is thoroughly rinsed with acetone and distilled water between samples.

- (iii) Composite Samples

Will be obtained using an automatic sampler equipped with a refrigerated compartment according to MISA specifications. Tubing to the sampler will be teflon and the sample will be collected in a glass 4L HPLC water bottle that has been previously used for the field blank. Should NDMA be detected in the field blanks, appropriate washing procedures will be employed.

- (iv) Field Blanks

The frequency of blank collection will be reviewed periodically.

- a) Grab Samples

Field blanks will be prepared by completely filling new 1 L amber bottles with unopened ultrapure HPLC water during sampling at the sample location.

- b) Composite Samples

Will consist of exposing previously-sealed ultrapure HPLC water to the atmosphere over the collection period. The volume of HPLC water used will be similar to that collected for the composite. The field blank will be contained in the fridge compartment of the sampler beside the composite container.

1.2.3 Split Samples Requested by the MoE

Samples will be collected during the 24 hour period just prior to delivery to the MOE laboratory (ie. Monday's sample will be collected over Sunday and Monday). Samples will be transported to the MOE lab by the Technical Assessment staff who will co-ordinate sample pick-up and legal chain of custody.

Where the MoE has requested split samples the legal aspects of the composite sampling will include applying a MOE legal seal over the fridge door of the automatic sampler. Only technical assessment staff will break this seal to remove

the sample for dispensation into the 1 L amber sample bottles. Appropriate MOE legal chain of custody procedures will be followed. Grab samples must be collected shortly before delivery to the MoE and 24-hour composites timed so that the last sample of the composite is also taken just before delivery to the MoE. Delivery of any samples to the MoE should be by 4:00 p.m., Monday to Friday.

1.3 Preservation and Transportation

- (i) All samples including those in amber bottles should have minimal exposure to "any" light.
- (ii) Samples should be transported in coolers with ice packs.
- (iii) Samples must not freeze.
- (iv) Samples must be delivered by hand or shipped by a reputable courier only when the same or next day delivery can be guaranteed. Do not ship on Friday or Saturday unless other arrangements have been made.
- (v) Delivery to the laboratory must be within 48 hours unless otherwise agreed on with the Project Manager. Hand-delivered on the same day is preferred.
- (vi) Ultimate preservation is the same as that at the laboratory: refrigeration at 4°C.
- (vii) Allowable storage time will be 14 days, including instrumental analysis time.

1.4 Chain-of-Custody

1.4.1 Sample Label

Sample labelling procedures are discussed in Section 1.1.3.

1.4.2 Chain of Custody Record Form

The following fields must be used as a minimum:

- (i) date and time of sampling
- (ii) sampling location and description
- (iii) sampler's signature
- (iv) type of analysis required
- (v) sample matrix
- (vi) miscellaneous notes to lab personnel
- (vii) laboratory sample custodian's signature
- (viii) date and time received at laboratory
- (ix) preservation used
- (x) project name/number
- (xi) who is to receive report of analysis
- (xii) required turnaround time
- (xiii) laboratory project name and number

This record accompanies the sample from the field to the laboratory.

1.4.3 Sampler's Log Book

The sampler's log should contain all of the information on the chain-of-custody. Just as important is a log of site conditions and any anomalies encountered during sampling. Other fields that should be considered are:

- sample withdrawal procedure/equipment
- date and time of collection
- sampling sequence
- field observations on sampling event
- climatic conditions including air temperature
- potential biases

1.5 Field Quality Assurance

1.5.1 Travelling Blanks

(i) Preparation

To be prepared in the laboratory by trained laboratory personnel.

- (a) Using a clean bottle previously washed with the protocol set forth in this document.
- (b) Label as "Travelling Blank" with the date and time prepared and that person's initials.
- (c) Use only organic-free water that has been previously tested (ie. laboratory blank) and determined to be free from interferences or contamination.
- (d) A seal is applied to the travelling blank and is initialled and dated by laboratory staff.

(ii) Sampling

The Travelling Blank is to be taken with the cooler/ice pack to the sampling site and opened/exposed during the sampling and be within 6 feet of the actual sampling site ie. the seal should be broken.

(iii) Frequency

- (a) Composite travelling blanks are not allowed.

A separate travelling blank will be taken at each sampling site.

These travelling blanks will be submitted with the samples but not analyzed except if their respective sample shows a NDMA concentration in excess of 9 ppt. If the travelling blank result is less than 3 ppt, then the respective sample result would be corrected with the travelling blank. If the travelling blank result is greater than 3 ppt, then resampling would take place. A subsequent action would be initiated if the corrected NDMA concentration exceeds the 9 ppt limit.

- (b) Each site must have one Travelling Blank or Composite Travelling Blank for every ten sampling dates at any location.
- (c) The QA/QC coordinator at the Uniroyal Laboratories is to be informed of any positive identifications in a Travelling Blank and can request alterations to the frequency of the Travelling Blanks. This requirement may be changed in the future after discussion between the MoE and Uniroyal.

(iv) Travelling Spikes

This aspect will be handled as a project under the direction of the QA/QC coordinator and the QC/QC Task Manager.

(v) Replicate Samples

- (a) Replicate samples are defined as samples taken in two separate bottles, at the same location, and taken at essentially the same time.
- (b) replicates are recommended to provide a back-up sample:
- (i) in case of breakages during shipment
 - (ii) for possible re-analysis
 - (iii) for periodic review of laboratory precision
- (c) Replicate samples are taken when required due to questionable results.
- All replicate analyses must be reported to the QA/QC coordinator.

1.6 Legal Aspects of Sampling Protocol

The purpose of legal sampling is to ensure that the sample bottles or the sample itself can not be tampered with and the sample collected in the field is the same sample as analyzed and reported in the lab.

(i) Laboratory Aspects

- (a) A logbook is set up to record each bottle that is washed, the date washed and by whom.
- (b) After each bottle is washed and capped (see Section 1.1.1) a label is applied showing the originating lab and the bottle identification number.
- (c) One bottle from each lot is submitted to the sample custodian for a "bottle check analysis". After proving by GC/MS that the bottle is free of the analyte, the bottle lot is released for sampling purposes.
- (d) Each lot of bottles is placed in labelled storage container.
- (e) The storage containers are then placed in a locked room.
- (f) A laboratory staff member must be present for distribution of the bottles to the field staff.
- (g) The requested number of bottles are placed into coolers (including travelling blanks and travelling spikes) and are then locked by the field staff.

Note: The travelling blank and travelling spike samples shall have a security seal applied after preparation by laboratory staff.

(ii) Field Aspects

- (a) After samples are collected, a security seal is applied and the samples are immediately placed in a locked cooler. Coolers must be kept locked at all times.
- (b) Sample coolers are placed inside the van (not the field trailer) and then transported to the laboratory the same day as sample collection.
- (c) When the locked coolers are returned to the laboratory the key is signed off from the field staff to the sample custodian.
- (d) Field staff must be present when the samples are unpacked from the locked coolers.
- (e) All sample seals are inspected by the laboratory sample custodian and are signed accordingly.
- (f) See the Analytical Protocol Subtask 1.16 for further handling of legal samples as they pass through the laboratory.

(iii) Emergency Bottle Usage by Field Staff

- (a) One lot of bottles (approximately 30 bottles) will be placed in a storage container.

- (b) The container will be stored in the offices of the field staff at the Uniroyal Laboratories.
- (c) These bottles are to be used ONLY if there is no lab staff available (ie. after hours or on weekends) to distribute and log the bottles.
- (d) A travelling blank sample may be prepared by field staff on such occasions ONLY if the field staff member has been trained by laboratory personnel in the appropriate techniques.
- (e) This travelling blank must have a security seal applied with the date of preparation and the initials of the prep person. This information must also be documented on the sample of chain-of-custody form.

**ANALYTICAL PROTOCOL FOR THE DETERMINATION OF
N-NITROSODIMETHYLAMINE (NDMA) IN AQUEOUS SAMPLES
BY GAS CHROMATOGRAPHY/HIGH RESOLUTION
MASS SPECTROMETRY**

1.0 SUMMARY

1.1 Principle of the Method

A sample is prepared by filtration to remove particulates. After the pH is adjusted to 12 to keep the acidic components in the aqueous phase, the basic solution is serially extracted with dichloromethane. The dichloromethane extract is then washed with a sulfuric acid solution to remove basic components from the organic phase. This is followed by filtration of the extract through anhydrous sodium sulfate to remove water, and concentration by rotary evaporator and a nitrogen evaporating unit. The sample extract containing the remaining neutral components is analyzed by gas chromatography/high resolution mass spectrometry (GC/HRMS). NDMA is quantified using the isotope dilution method of analysis.

This method is designed to identify and quantify N-nitrosodimethylamine (NDMA) in aqueous samples by extraction with an organic solvent and analysis of the concentrated extract by GC/HRMS.

1.1.1 Relationship to Other Methods

N-nitrosodimethylamine can be analyzed by spectrophotometry, thin layer chromatography (TLC), gas chromatography (GC) with various detectors [FID, NPD, Hall, thermal energy analyzer (TEA)], or gas chromatography/mass spectrometry (GC/MS). The Mass Spectrometry Laboratory at the Ministry of the Environment (MOE) uses GC/HRMS to differentiate NDMA from chemical interferences.

1.2 Parameters Measured

N-nitrosodimethylamine (NDMA).

Results are reported in $\mu\text{g/L}$.

1.3 Sample Matrices

This method is used for aqueous samples.

1.4 Sample Requirements

1.4.1 Specifications

Samples are collected in one litre amber bottles with Teflon-lined caps. If non-amber bottles are used, the samples must be protected from light by placement in an aluminum foil wrapper or in a light-tight cardboard box.

The samples should be stored at 4⁰ C.

Time required for analysis:

- | | |
|---------------------------|--|
| 1) Extraction and workup | - 8 samples plus 1 procedure blank per 11 hour day |
| 2) Instrument set-up time | - tuning, calibration: 1.5 - 2 hours |
| 3) Instrument analysis | - 35 minutes/run |
| 4) Data processing | - manual - 0.5 - 1 hour |

1.4.2 Contingencies

Not applicable

1.5 Shortcomings

1.5.1 Interferences

The exact masses for NDMA and a common ester fragment are m/z 74.0480 ($C_2H_6N_2O$) and m/z 74.0368 ($C_3H_6O_2$) respectively. On a single quadrupole mass spectrometer, which is restrictive to low resolution mass spectrometry (LRMS), these masses are indistinguishable from each other. The mass resolution required to differentiate these masses is 6,607 [$74/(74.0480-74.0368)$]. Operation of a high resolution mass spectrometer at a mass resolution of 7,000 allows NDMA to be differentiated from chemical interferences such as $C_3H_6O_2$. In this way, the HRMS technique can circumvent problems resulting from false positives and false negatives in LRMS. Therefore, the HRMS technique is more selective than the LRMS technique.

Contamination of the sample may result if the screw cap is not lined with Teflon or if the screw cap is loose.

The use of high purity reagents and solvents is essential in minimizing interferences.

1.5.2 Biases

This isotope dilution method of analysis is used. This requires that a known amount of an isotopically-labelled analogue (d_6 -NDMA) of the analyte (NDMA) is added to the matrix prior to sample manipulation. The d_6 -NDMA are corrected for response factor (signal strength) and recovery (extraction efficiency).

The ratio of NDMA to d_6 -NDMA should be close to 1:1 in order to obtain highly accurate results.

1.5.3 Limitations

This method is restricted to aqueous samples.

1.6 Analytical Performance Summary

1.6.1 Single analyst (within-run) precision

A series of HPLC grade water samples were spiked at the 12.4 ppt level. The mean for 8 replicate samples was 13.8 ppt with a standard deviation of 0.8 ppt (5.8%).

1.6.2 Between-Run Precision (Samples)

A spiked HPLC water sample extract was analyzed on 12 consecutive days ($n=12$). The mean was 73.0 ppt with a standard deviation of 4.0 ppt (5.5%).

1.6.3 Between-Run Precision (Typical Samples)

A groundwater sample extract was analyzed on 12 different days ($n=12$). The mean was 586 ppt with a standard deviation of 83.7 ppt (14%).

1.6.4 Linear Dynamic Range

A series of NDMA standards was analyzed at concentrations from 2 pg to 40 ng. From these data, the linear dynamic range was determined to be greater than four orders of magnitude.

1.6.5 Instrument Detection Limit (IDL)

The instrument detection limit was determined by analyzing a sample extract having a concentration of approximately 8 ppt. The mean NDMA concentration was found to be 7.9 ppt with a standard deviation of 0.2 ppt (2.9%). Using the Student's value for a 99% confidence level, the instrument detection limit was calculated to be 0.7 ppt.

1.6.6 Method Detection limit (MDL)

Laboratory procedure blanks were processed and analyzed with batches of routine samples. The mean NDMA concentration (n=166) was 2.0 ppt. Using the MOE MISA detection limit (MDL) protocol (1.7.7), the MDL at the 99% confidence level was determined to be 5 ppt.

1.7 Bibliography

- 1.7.1 IARC Monograph on the evaluation of carcinogenic risk of chemicals to man, Vol. 1, p. 85.
- 1.7.2 Freund, H.A., Ann. Intern. med., 10, 1144 (1937).
- 1.7.3 Magee, P.N., Barnes, J.M., "Carcinogenic nitroso compounds", Advanc. Cancer Res. 10, 163 (1967).
- 1.7.4 Fazio, T. et al, J. Food Chem., 19, 250 (1971).
- 1.7.5 Garrison, A.W., Environmental Research Laboratory, Athens, Ga., Quarterly Research Summary, October-December 1976, p. 4.
- 1.7.6 Environment Ontario, Laboratory Environmental Awareness File No. 0-W-005.
- 1.7.7 Environment Ontario, Estimation of Analytical Method Detection Limits (MDL), ISBN 0-7729-4117-3

1.8 History of Changes/Revisions

This is the first publication of this method.

2.0 SAMPLE PREPARATION

NOTE: Equipment equivalent to that used in this method is acceptable.

2.1 Labware

- 2.1.1. Funnel, separatory, with Teflon stopcock, 1 L.
- 2.1.2 Flask, round bottom, with TS 24/40 ground glass joint, for rotary evaporator, 250 mL or 300 mL.
- 2.1.3 Flask, Erlenmeyer, 250 mL.

- 2.1.4 Funnel/glass wool (for particulates).
- 2.1.5 Funnel, for glass wool and sodium sulfate.
- 2.1.6 Vial, with Teflon-lined cap, 2 mL.
- 2.1.7 Glass wool, pre-extracted with dichloromethane.
- 2.1.8 Pipette, Pasteur.
- 2.1.9 Bulb, rubber, 1 mL
- 2.1.10 Syringe, Hamilton, Gastight, 10 μ L.
- 2.1.11 Cylinders, graduated, 25 mL, 100 mL, 250 mL and 1000 mL.

2.2 Reagents

- 2.2.1 Sodium hydroxide, NaOH, 50%.
- 2.2.2 Sulfuric acid, H₂SO₄, 50%.
- 2.2.3 Dichloromethane, CH₂Cl₂, distilled-in-glass.
- 2.2.4 Sodium sulfate, Na₂SO₄, anhydrous, granular, pre-extracted with dichloromethane.
- 2.2.5 Nitrogen, n₂, ultrahigh purity (UHP).

2.3 Equipment

- 2.3.1 Evaporator, rotary (Buchi), with temperature-controlled water bath.
- 2.3.2 Evaporating unit, Pierce Model 18780 Reacti-Vap and Reacti-Therm.

2.4 Extraction Procedure

NOTE: All glass ware is cleaned in a detergent solution. This is followed by rinses with tap water and methanol. Prior to use in the extraction procedure, the glassware is rinsed with dichloromethane. All work is to be done in a fumehood.

- 2.4.1 For each batch of eight samples, a procedure blank consisting of 800 mL of HPLC grade water is used.

This procedure blank is then treated as if it were a routine sample as described below.

2.4.2 For samples containing ppt levels, an 800 mL volume is taken.

For samples containing ppb levels, a smaller volume (10 mL minimum) is used. The volume used is such that the expected NDMA/d₆-NDMA ratio is approximately 1:1. See Section 2.4.5.

2.4.3 The sample is filtered through glass wool directly into the separatory funnel.

2.4.4 For sample volumes less than 800 mL, HPLC grade water (to make up to 800 mL) is filtered through the glass wool after the sample.

2.4.5 For low ppt levels of NDMA (<100 ppt), the internal standard d₆-NDMA is added [10 µL of a 6.67 ng/µL solution in methanol (5.4.8) is used for a total of 66.7 ng (83.4 ppt)]

For high ppt levels (100-1000 ppt), the internal standard d₆-NDMA is added [10 µL of a 53.3 ng/µL solution in methanol (5.4.7) is used for a total of 533 ng (666 ppt)].

For ppb levels, see Section 2.4.2.

2.4.6 The separatory funnel is stoppered and the contents are mixed thoroughly.

2.4.7 The pH of the sample is adjusted to 12 with a dropwise addition of 50% sodium hydroxide solution. The pH is checked with pH paper.

2.4.8 The sample is serially extracted with dichloromethane (80 x 40 x 40 mL).

2.4.9 The extracts including emulsions are collected in a 250 mL Erlenmeyer flask.

2.4.10 The aqueous fraction is discarded.

2.4.11 The extract/emulsion is poured back into its respective separatory funnel.

2.4.12 The dichloromethane fraction (without the emulsion) is collected in the same 250 mL Erlenmeyer flask as before.

2.4.13 The emulsion is discarded.

2.4.14 The separatory funnel is rinsed with HPLC grade water. This rinse is drained through the stop-cock.

- 2.4.15 The dichloromethane fraction is transferred back into the separatory funnel.
- 2.4.16 A pH 2 solution of sulfuric acid is prepared in HPLC grade water. A 100 mL portion of this solution is added to the separatory funnel.
- 2.4.17 The contents are shaken thoroughly and the phases are allowed to settle.
- 2.4.18 The dichloromethane fraction is filtered through anhydrous sodium sulfate (prerinsed with dichloromethane) into a 250 mL round bottom flask.
- 2.4.19 The extract is concentrated to approximately 1 mL on a rotary evaporator.
- 2.4.20 The concentrate is transferred to a 2 mL vial (Teflon-lined cap).
- 2.4.21 The flask is rinsed with additional dichloromethane and the rinses are transferred to the same vial.
- 2.4.22 The extract is concentrated to 200 μ L under a stream of UHP nitrogen.

3.0 ANALYTICAL PROCESSING

No further processing of the samples is required before submitting them to the detection system.

4.0 DETECTION SYSTEM

NOTE: The GC/HRMS equipment must be operated by personnel skilled in its use and optimization.

4.1 Labware

- 4.1.1 Syringe, Varian, on-column injector, 5 μ L with a fused-silica needle (sheathed with stainless steel).

4.2 Reagents

- 4.2.1 Methanol, CH₃OH, distilled-in-glass.
- 4.2.2 Dichloromethane, CH₂Cl₂, distilled-in-glass.
- 4.2.3 N-nitrosodimethylamine (NDMA), Aldrich Gold Label (5.2.1).
- 4.2.4 d₆-N-nitrosodimethylamine (d₆-NDMA), MSD Isotopes (5.2.2).

4.2.5 Helium, He, ultrahigh purity (UHP).

4.2.6 Calibration Standard Solution.

Solution (5.4.5) contains 267 pg/ μ L of NDMA and d₆-NDMA.

4.3 Equipment

4.3.1 Mass Spectrometer: VG ZAB-2F (double-focusing, magnetic sector mass spectrometer).

4.3.2 Gas chromatograph: Varian 6000, with an on-column injector.

4.3.3 Column: J&W Scientific DB-1701, 30m, 0.25 mm i.d., 0.25 μ film thickness.

4.4 Instrument Set-Up Procedures

4.4.1 Gas chromatograph Set-Up.

The gas chromatograph is set to the following conditions:

Injection system:	on-column
Column head pressure:	10 psi
Carrier gas:	helium

Injector program:

- initial temperature: 30°C
- to 230°C @ 180°C/min.; hold 16 min.

Interface:

- direct @ 280°C

Column oven temperature program:

- initial temperature: 40°C; hold 1 min.
- to 100°C @ 8°C/min.
- to 280°C @ 30°C/min.; hold 3 min.

4.4.2 Mass Spectrometer Set-Up.

The Mass Spectrometer is set to the following conditions:

Ionization mode:	electron impact
	positive ions
(Mass) resolution:	7,000 RP

Ions monitored: (dwell time in brackets)

m/z 68.9952 for PFTBA	(lockmass)
	(50 msec.)
m/z 74.0480 for NDMA	(100 msec.)
m/z 80.0857 for d ₆ -NDMA	(50 msec.)
m/z 68.9952 for PFTBA	(lockmass check)
	(20 msec.)

Source temperature:	250°C
Transfer line temperature:	280°C
Electron energy:	70 eV
Electron multiplier:	2.5 kV
FA3 amplifier:	10 ⁻⁶ AFS

4.5 Daily Tuning and Calibration Procedure for the Mass Spectrometer

- 4.5.1 The system is turned on by switching from STANDBY to OPERATE.
- 4.5.2 The isolation valve between the source and the analyzer is opened.
- 4.5.3 The system is leak checked; the ratio of He: air must be >10:1 (typically 50:1).
- 4.5.4 The mode selector is set to PMU/EHT.
- 4.5.5 The Peak Matching Unit is set to the 10⁵ range and to alternate (ALT) between the low and high masses.
- 4.5.6 The reference compound perfluorotributylamine (PFTBA) is allowed to bleed in from the septum inlet.
- 4.5.7 The system is allowed to stabilize for 30 min.
- 4.5.8 The m/z 68.9952 peak is centred in the middle of the oscilloscope by using the MANUAL magnet controls.
- 4.5.9 The PMU is switched to the 10³ range to obtain a reasonable peak width. Step 4.5.8 is repeated if necessary.

- 4.5.10 The mass spectrometer is tuned to $> \text{ or } = 7,000$ RP on m/z 68.9952.
 - 4.5.11 The data system control is set up by switching the mode selector to DIGITAL/MAG, the EHT to EXTERNAL and the PMU to OFF.
 - 4.5.12 The new file number is entered into the system program.
 - 4.5.13 The zero on the FA3 amplifier is set to between 0000 and 0001 with the HI OFF.
 - 4.5.14 A mass calibration is done using PFTBA.
- 4.6 NDMA Procedure
- 4.6.1 The valve on the CO₂ cylinder is opened (for injector cooling).
 - 4.6.2 The GC and the injector are set to the initial parameters in 4.4.1.
 - 4.6.3 The syringe is rinsed 5 times with dichloromethane.
 - 4.6.4 The following are drawn up into the syringe: 1.0 μL dichloromethane, 0.4 μL air, 2.0 μL of the calibration standard (5.2.9) and 0.4 μL air.
 - 4.6.5 The outside of the syringe needle is rinsed with dichloromethane and then wiped dry with a Kim-Wipe.
 - 4.6.6 The mass spectrometer is switched to STANDBY.
 - 4.6.7 The contents of the syringe are injected at a rate of 0.2 $\mu\text{L}/\text{sec}$.
 - 4.6.8 The data system is started by typing SYS^G.
 - 4.6.9 The injector/GC combination is started by pressing RESET, then START.
 - 4.6.10 When the injector temperature is $> 50^{\circ}$, the syringe is withdrawn.
 - 4.6.11 The outside of the syringe is rinsed with dichloromethane.
 - 4.6.12 The syringe is rinsed 20 times with dichloromethane.
 - 4.6.13 When the vacuum in the source has stabilized at 2×10^{-6} , the mass spectrometer is switched to OPERATE.

4.6.14 For each run (sample), the ion chromatograms for NDMA (m/z 74.0480) and d_6 -NDMA (80.0857) are displayed. The areas of the peaks are determined manually. The sample description is entered in the text slot. The completed run is printed out.

4.6.15 Steps 4.6.3 to 4.6.14 are repeated for each sample and standard.

4.6.16 After the last standard has been run, the acquisition is terminated by switching the mass spectrometer to STANDBY and the mode selector to ANALOG/MAG, by closing the isolation valve and the valve to the septum inlet and by re-setting the GC column and injector to 160° . The valve to the CO_2 cylinder is closed.

5.0 CALIBRATION AND STANDARDIZATION

5.1 Labware

5.1.1 Flasks, volumetric, 10.0 mL, 25.0 mL, 50.0 mL, 100.0 mL.

5.1.2 Vial, with Teflon-lined cap, 2 mL.

5.1.3 Pipette, volumetric, 0.5 mL, 1.0 mL, 2.0 mL.

5.2 Standards and Reference Materials

5.2.1 Methanol, CH_3OH , distilled-in-glass.

5.2.2 Dichloromethane, CH_2Cl_2 , DISTILLED-IN-GLASS.

5.2.3 N-nitrosodimethylamine (NDMA):

Aldrich Gold Label

N_2 , 500-1 (25 g)

99 + %

5.2.4 d_6 -N-nitrosodimethylamine (d_6 -NDMA):

MSD Isotopes

MD-2937 (0.1 g)

99.6% D

5.2.5 A solution of NDMA was prepared:

5.2.6 A solution of d_6 -NDMA was prepared:

83.3 mg/10.0 mL in MaOH (8330 ng/ μ L)

- 5.2.7 A solution of NDMA /d₆-NDMA was prepared by taking 2.0 mL of (5.2.5) and 2.0 mL of (5.2.6) and diluting to 25.0 mL with CH₂Cl₂. (666ng/μL)
- 5.2.8 A solution of NDMA/d₆-NDMA was prepared by taking 1.0 mL of (5.2.7) and diluting to 25.0 mL with CH₂Cl₂. (26.7 ng/μL)
- 5.2.9 A solution of NDMA/d₆-NDMA was prepared by taking 1.0 mL of (5.2.8) and diluting to 100.0 mL with CH₂Cl₂. (267 pg/μL).
- 5.2.10 A solution of d₆-NDMA was prepared by taking 2.0 mL of (5.2.6) and diluting to 25.0 mL with MeOH. (666 ng/μL)
- 5.2.11 A solution of d₆-NDMA was prepared by taking 2.0 mL of (5.2.10) and diluting to 25.0 mL with MeOH. (53.3 ng/μL)
- 5.2.12 A solution of d₆-NDMA was prepared by taking 1.0 mL of (5.2.10) and diluting to 100.0 mL with MeOH. (6.66 ng/μL)
- 5.2.13 A solution of d₆-NDMA was prepared by taking 0.5 mL of (5.2.5) and diluting to 100.0 mL with MeOH. (41.7 ng/μL)
- 5.2.14 A solution of d₆-NDMA was prepared by taking 1.0 mL of (5.2.13) and diluting to 50.0 mL with MeOH. (0.833 ng/μL)

5.3 Equipment

- 5.3.1 Balance, analytical (accurate to 0.1 mg).

5.4 Procedure for Standardization and Calibration

- 5.4.1 2 uL of the calibration standard (5.2.9) with NDMA/d₆-NDMA (267 pg/μL/267 pg/μL) is injected into the GC/HRMS system to monitor the chromatographic performance and the instrument sensitivity (signal strength/pg injected).

6.0 RUN PROCESSING AND QUALITY ASSURANCE

6.1 Run Format

The daily run format includes a calibration standard (5.2.9), blanks (2.4.1), samples and a repeat of the calibration standard (5.2.9).

6.2 Run Control Operations/Limits

- 6.2.1 If the chromatography is poor (exemplified by severe peak tailing), the GC column is shortened at the front end or the column is replaced. The He head pressure on the column is reduced as the column is shortened in order to optimize the chromatography and sensitivity.
- 6.2.2 If the sensitivity of the mass spectrometer is poor (must be able to detect 1 ppt in the procedure blank) and the chromatography has been optimized, the MS is returned or the ion source is cleaned.
- 6.2.3 If sufficient resolution (7,0000) and sensitivity cannot be attained, the ion source and/or source slit must be cleaned.
- 6.2.4 The ratio of NDMA/d₆-NDMA in the repeat calibration standard must be within 5% of the first standard. Otherwise, the standard and the samples must be reinjected.

6.3 Calculations

- 6.3.1 A calibration factor is determined by the formula listed below:

$$\text{Calibration Factor} = \frac{\text{Area (d}_6\text{NDMAstd)}}{\text{Area (NDMAstd)}} \times \frac{\text{Conc (NDMAstd)}}{\text{Conc (d}_6\text{NDMAstd)}} \times \frac{\text{ng(d}_6\text{NDMA) added to sample}}{\text{sample vol. (in mL)}}$$

- 6.3.2 The formula detailed below is used to obtain a final sample concentration of NDMA in µg/L.

$$\text{Concentration of NDMA in } \mu\text{g/L} = \frac{\text{Area of NDMA in sample}}{\text{Area of d}_6\text{NDMA in sample}} \times \text{Calibration Factor}$$

6.4 Reporting

- 6.4.1 All results are reported in µg/L. the non-detected (ND) results are reported with the appropriate detection limits in parentheses.

6.5 Proficiency Testing

- 6.5.1 The sample preparation technician is trained by the supervisor. His/her proficiency is assessed by observations of the analysis in progress and by evaluation of the laboratory procedure blanks.

6.5.2 The instrumental analyst is trained by the supervisor. His/her proficiency is assessed by observations of the analysis in progress and by evaluation of the interpreted results.

Interim Order

FILES:SWA.011.89
SWA.013.89
SWA.014.89

ENVIRONMENTAL APPEAL BOARD

IN THE MATTER OF the **Ontario Water Resources Act** (R.S.O. 1980, c.361) as amended;

- and -

IN THE MATTER OF an application by **Uniroyal Chemical Ltd.** dated January 12, 1990, and amended January 19, 1990 at 09:30 hours, for a hearing before the Environmental Appeal Board with respect to an **Emergency Direction** dated December 30, 1989 from the Director, Hamilton Regional Office, Ministry of the Environment under s.32(1) of the **Ontario Water Resources Act** as amended;

- and -

IN THE MATTER OF an application by **Uniroyal Chemical Ltd.** dated January 19, 1990 at 11:20 hours, for a hearing before the Environmental Appeal Board with respect to a **Director's Notice** dated January 18, 1990 from the Director, Hamilton Regional Office, Ministry of the Environment under s.8 of the **Ontario Water Resources Act** as amended;

- and -

IN THE MATTER OF an application by **Uniroyal Chemical Ltd.** dated February 9, 1990 for a hearing before the Environmental Appeal Board with respect to the **Director's Notice/Order** dated January 26, 1990 and February 2, 1990 from the Director, Hamilton Regional Office, Ministry of the Environment issued under the **Ontario Water Resources Act**.

BEFORE:

Knox M. Henry, Chair
Barry J. Adams, Member
Mary C. Schwass, Member

Sitting in the Auditorium of St. James Lutheran Church, 60 Arthur Street South, Elmira, Ontario, on Friday, August 17, 1990.

APPEARANCES:

W.A.Derry Millar	)	for the Appellant
J.G. Cowan	)	Uniroyal Chemical Ltd.
J.M. Buhlman	)	

S.D. Berger	)	for the Ministry of
S. Ficek	)	the Environment
S. McNamee	)	

H. Poch	)	for the Regional
C. Albert	)	Municipality of
E. Moore	)	Waterloo
R. Power	)	

T.C. Flannery	)	for APTE
S. Rupert	)	
P. Potter	)	

T.R. Lederer	)	for Sundor Canada Inc.
D. Hamilton	)	

S. Garrod	)	for the Township of Woolwich
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UNIROYAL CHEMICAL LIMITED

INTERIM ORDER

The Board orders that exhibit 123, the proposed Interim Order, is amended as follows:

1. Discharges by Uniroyal Chemical Ltd. to the Elmira Sewage Treatment Plant (STP) shall be permitted in sequence as follows:
 - (a) The existing, 5,000 gallons of carbon-treated carboxin (Vitavax) wastewater;
 - (b) the existing 400,000 gallons of UV: H_2O_2 treated general wastewater (equalization tank); and
 - (c) any other wastewater that is pre-analyzed and batched in conformity with paragraph 2 herein.
2. Such discharges shall only occur if in compliance with the terms and conditions of Uniroyal Chemical Ltd.'s "Interim Wastewater Treatment Plan/Compliance Plan" (exhibit 102) as amended by the Council of the Regional Municipality of Waterloo on June 14, 1990 (exhibit 103), except that discharges of NDMA at levels greater than 0.5 ppb are not permitted and except that clause No. vi on pages 4 and 5 of exhibit 103 does not apply.
3. No discharges of wastewater mentioned in paragraphs 1(a), 1(b) and 1(c) herein shall occur until such wastewater has been re-tested and re-analyzed for NDMA to the satisfaction of the MoE Director, West Central Region. Any reasons for denying authorization to discharge on the basis of the sampling results for NDMA shall be immediately communicated in writing to the Board and all of the parties to the hearing.
4. This interim order does not permit Uniroyal Chemical Ltd.'s contravention of any municipal, provincial or federal law.
5. If any effluent discharge from the Elmira STP in the said Director's opinion - based on validated laboratory data - contains NDMA in concentration greater than 0.5 ppb, or in a concentration in exceedence of the number selected by the Director, West Central Region, Ministry of the Environment, to conform with any amendment to the Ministry's of the Environment's Interim Drinking Water Guideline - (notice of any amendment made to the Interim Drinking Water Guideline shall be communicated to Uniroyal 48 hours before implementation date of the amendment) - all discharges by Uniroyal Chemical Ltd. to the Elmira STP

shall cease forthwith upon being notified by said Director or by any other MoE official.

6. Uniroyal shall notify all parties of the date of any planned commencement of discharge of effluent to the Elmira Sewage Treatment Plant.
7. Three tests must be done by the Ministry of the Environment of the water in the Grand River at Woolner Flats during the week prior to the commencement of any discharge by Uniroyal. Once discharge has commenced by Uniroyal the Ministry of the Environment shall test the water in the Grand River at Woolner Flats three times a week.
8. The Ministry of the Environment shall by agreement provide results of any testing of effluent, water, or wastewater to all parties and the Board within 72 hours of the time of sample collection.
9. The Ministry of the Environment is directed to expedite the approval process for other labs for testing of NDMA.
10. Uniroyal shall discharge the carbon treated carboxin (Vitavax) wastewater first, followed by the wastewater in the equalization tank.

REASONS:

In the Board's view, the Interim Order as amended contains terms and conditions that are more stringent than the terms and conditions of the original order of December 30, 1989. Thus, it appears the Interim Order is more in the public interest.

Further, the Interim Order provides a staged discharge of Uniroyal's wastewater with controls that appear to provide the best practical assurance for the protection of the public safety through compliance with the current drinking water standards. However, the Board is concerned about public safety and the source of the drinking water for the public in this region.

Clause 6 will provide the opportunity for all parties to be aware of the date of any impending discharge.

The Board recognizes that a 0.5 parts per billion level of NDMA in the effluent from Uniroyal to the Elmira Sewage Treatment Plant may affect the level of NDMA in the Grand River at Woolner Flats. The Board wants to monitor the effects of any discharge from Uniroyal on these levels of NDMA in the Grand River at Woolner Flats.

The Board feels that testing of the Grand River at Woolner Flats, as outlined in clause 7, should be done two or three times before any discharge of effluent to the Elmira Sewage Treatment Plant and then, as any discharge from Uniroyal is

occurring, there shall be regular monitoring at Woolner Flats. It is the Board's understanding that there are potentially other sources of NDMA to the Grand River and the Board wants to view the effect of any discharges upon the NDMA levels in the river, if there is any, of the Uniroyal discharge to the Elmira Sewage Treatment Plant.

The Board in agreeing to the Interim order as amended does so on the clear understanding that its adoption does not prejudice the position of any parties to this hearing, nor prejudice the final decision of the Board.

Further, should the Director during the period of implementation of this Interim Order advise Uniroyal of new Provincial Drinking Water Guidelines and the effect of the guidelines are unacceptable to Uniroyal, Uniroyal may make application to this Board to appeal those guidelines and the Board will endeavour to hear any such application as quickly as possible.

In conclusion, the Board feels the adoption of this Interim Order will provide a test of the effectiveness of the ultraviolet hydrogen peroxide, or UV: H₂O₂ treated system, while still providing adequate safeguards to protect the public.

[signed]

KNOX M. HENRY, Panel Chair

[signed]

PROF. BARRY J. ADAMS, Member

[signed]

Dr. MARY C. SCHWASS, Member

DATE: September 6, 1990

EMERGENCY DIRECTION ISSUED BY THE DIRECTOR UNDER S.32(1) OF
THE ONTARIO WATER RESOURCES ACT R.S.O. 1980 C.361 AS AMENDED

TO: UNIROYAL CHEMICAL LTD., ELMIRA, ONTARIO

PART I: STATUTORY AUTHORITY

Section 32(1) of the Ontario Water Resources Act, R.S.O. 1980, c.361 as amended provides that:

"Sewage works shall at all times be maintained, kept in repair and operated in such manner and with such facilities as may be directed from time to time by a Director."

Section 1(s) of the same Act provides that:

"Sewage works" means any works for the collection, transmission, treatment and disposal of sewage, or any part of any such works, but does not include plumbing or other works to which the regulations made under clause 44 (2)(a) apply;"

Section 1(r) of the Act provides that:

"Sewage" includes drainage, storm water, commercial wastes and industrial wastes and such other matter or substance as is specified by regulations made under clause 44 (1)(i);"

Section 61(1) of the Act provides that:

"Where a Director intends to make, give or issue a direction, order, report, or notice, other than an emergency order, he shall serve notice of his intention together with written reasons therefore upon the person to whom he intends to make, give or issue the direction, order, report, or notice and shall not make, give or issue the direction, order, report or notice until fifteen days after the service of thereof and such person may make submissions to him at any time before the making, giving or issuing of the direction, order, report or notice."

Section 62(1) of the Act provides that:

"In this section and in section 61, "emergency order" means an order, direction, report, or notice issued, made or given under this Act in an emergency by reason of,

- (a) danger to the health or safety of any person;
- (b) impairment or immediate risk of impairment of any waters or the use thereof;
- (c) injury or damage or immediate risk of injury or damage to any property or to any plant or animal life."

Section 62(2) of the Act provides that:

"The commencement of a proceeding before the Environmental Appeal Board does not operate as a stay of an emergency order"

Section 66(2) of the Act provides that:

"Every person that fails to comply with an order, notice, direction, requirement, or report made under this Act is guilty of an offence".

PART II: BACKGROUND

1. WHEREAS the sewage from Uniroyal Chemical Ltd. in Elmira flows through sewage works to the Elmira Sewage Treatment Plant and then downstream to Canagagigue Creek through Iron Bridge, and then into the Grand River and downstream to Freeport, Kitchener-Waterloo, Cambridge, Brantford, Oshwegan, and Cayuga.
2. WHEREAS N, nitrosodimethylamine (NDMA) has been detected in a sample taken from the Canagagigue Creek downstream at Iron Bridge on December 19, 1989 at .34 µg/L; in three treated samples in Kitchener-Waterloo on December 19, 1989 at .012, .069 and .008 µg/L; in two samples in Brantford on December 19, 1989 at .01 µg/L; in two samples in Oshwegan on December 20, 1989 at .033 and .32 µg/L and in samples in Cayuga, at .042 and .018 µg/L on December 19; .04, .012, .014, .014, .04, and .015 µg/L on December 22; and .019, .011 and .012 µg/L on December 27, 1989.
3. WHEREAS NDMA has been detected in the Elmira Sewage Treatment Plant effluent on November 30, 1989 at 50 µg/L and on December 19, 1989 at 1.1 µg/L and in the Sewage Treatment plant sludge at .9 µg/L on December 19, 1989.
4. WHEREAS no NDMA in Elmira town influent to the Sewage Treatment Plant was detectable at detection limits of .5 and .1 µg/L on either November 30 or December 19, 1989 respectively.
5. WHEREAS NDMA in the Uniroyal Chemical sewage to the Elmira Sewage Treatment Plant on November 30, 1989 was 2000 µg/L and greater than 300 µg/L on December 19, 1989. A sample taken at the carbon filter outflow on December 19, 1989 was analyzed as containing NDMA greater than 100 µg/L.
6. WHEREAS in a letter to Ms Ann Vajdic of the Ontario Ministry of the Environment dated November 19, 1989, Dr. R.S. Tobin, Acting Chief of the Monitoring and Criteria Division of Health and Welfare Canada, states at p.2: "However, based on the potent carcinogenicity of NDMA in experimental animals and its probable carcinogenicity in humans, it is recommended that exposure to this compound be minimized."
7. WHEREAS the U.S. Environmental Protection Agency has published an "Ambient Water Quality Criteria" of .0014 µg/L for NDMA.

8. WHEREAS human beings would be exposed to the water system from which samples of NDMA have been detected off the Uniroyal property in Elmira.
9. WHEREAS Uniroyal Chemical has, in a letter dated December 20, 1989 from R.F. Staples, Manager, Environmental Affairs of Uniroyal Chemical, to D. Ireland, admitted to having NDMA at their plant. He has also agreed in this letter to discontinue use of a source of NDMA, dimethylamine, at Uniroyal's premises.
10. WHEREAS the NDMA continues to appear in the sewage works leading to the Elmira Sewage Treatment plant.
11. WHEREAS Uniroyal has in the letter of December 20, 1989 referred to above, substantially agreed to many of the terms set out below and been advised of the terms prior to the issuance of this directive and given an opportunity to comment on their reasonableness.
12. WHEREAS I believe that these terms are necessary in order to ensure that the Uniroyal operations pose no danger to the health or safety of any person, impairment or immediate impairment of any waters, or injury or damage, or immediate risk of injury or damage to any property or to any plant or animal life.

PART III: TERMS OF THE ORDER

1. Discontinue use of dimethylamine or any other source of NDMA. Lock any area the source is stored in.
2. Inspect all dimethylamine process equipment to ensure that dimethylamine, or any other source of NDMA and NDMA are not gaining access to the process.
3. Sample and analyze Uniroyal Chemical's discharge to the Municipal Sewage treatment plant in Elmira, and the inlet to the Uniroyal Chemical aeration tank in Elmira, for NDMA 3 times weekly.
4. Sample and analyze all individual process effluents, as brought into operation, for NDMA and cease immediately any further discharges of any individual processes which exceed 10.0 µg/L.
Samples and analyses of individual process effluents shall be conducted, in any case, at least once a week to ensure compliance with the standard set out in this paragraph.
5. Take steps to set up in-house analytical capability to measure NDMA for the purpose of this order.
6. Analyze steam condensate and cooling tower water for NDMA, weekly.
7. Provide duplicate samples to Ministry of the Environment employees upon request.

8. Discontinue immediately any discharge into the Municipal Sewage Treatment plant, in the event that NDMA is detected in the Sewage Treatment Plant effluent at a level greater than .05 µg/L and any detectable quantity of NDMA is present in Uniroyal sewage.

Since the objective of this emergency order is ultimately to eliminate all discharges of NDMA, a review of the effluent standard set out in this paragraph will be carried out by the Director and this order would be varied, after notice, accordingly.

9. All analyses shall be performed by a laboratory acceptable to the Director.

10. All sampling referred to in this order must be acceptable to the Director.

11. Results of all analyses must be reported to the Director within 72 hours of the time a sample is taken.

12. Uniroyal Chemical will give access to the Uniroyal site in Elmira, to Ministry of the Environment staff upon request and provide a person who is capable of showing Ministry of the Environment staff any aspects of the operation which would relate to the ongoing inspection of potential sources of NDMA in the sewage, and sewage works.

PART IV: GENERAL

13. Section 61(2a) of the Ontario Water Resources Act provides that you may, by written notice served upon the Director and the Environmental Appeal Board, within fifteen days after the service by the Director of the above order, require a hearing of the Environmental Appeal Board.

14. The Director may, by written notice reduce the frequency of any sampling required under this order and may revoke any or all of the paragraphs or clauses in this order.

The revocation of a paragraph or a clause does not affect the validity of the remainder of the order.

15. This order comes into effect on Saturday, the 30th of December, 1989.

[signed " S. E. Salbach"]

S.E. Salbach, Director under
the Ontario Water Resources Act

[Notice of 1.18.90]

NOTICE UNDER EMERGENCY ORDER OF DIRECTOR DATED DECEMBER 30, 1989

TO: UNIROYAL CHEMICAL LTD., ELMIRA, ONTARIO

WHEREAS two sample have been obtained from the Elmira Municipal Sewage Treatment Plant indicating NDMA in excess of .5 µg/L and in particular: one sample taken January 12, 1990 contained 0.8 µg/L NDMA and confirmed in one sample taken January 15, 1990 contained 0.59 µg/L NDMA

WHEREAS detectable levels of NDMA have been found in Uniroyal sewage, in particular one sample taken January 12, 1990, contained 190 µg/L NDMA.

PURSUANT TO PARAGRAPH 8 of the Emergency order dated December 30, 1989, set out below I hereby notify you that you are obliged to immediately discontinue and discharge into the Municipal Sewage Treatment Plant in Elmira.

Failure to do so will be considered by me as an offence under s.66(2) of the Ontario Water Resources Act, R.S.O. 1980, c.361. Notice of such failure will be given to the Investigations and Enforcement Branch of the Ministry of the Environment for prosecution purposes.

SECTION 8 OF THE EMERGENCY ORDER PROVIDES AS FOLLOWS:

Discontinue immediately any discharge into the Municipal Sewage Treatment Plant, in the event that NDMA is detected in the sewage Treatment Plant effluent at a level greater than .5 µg/L and any detectable quantity of NDMA is present in Uniroyal sewage.

Since the objective of this emergency order is ultimately to eliminate all discharges of NDMA, a review of the effluent standard set out in this paragraph will be carried out by the Director and this order would be varied, with notice, accordingly.

Dated January 18, 1990, in Hamilton, Ontario

[signed: 'S. E. Salbach']

S.E. Salbach, Director
Ontario Water Resources

January 26, 1990

Mr. W.K. Ruck
General Manager
Uniroyal Chemical Ltd.
25 Erb Street
Elmira, Ontario
N3B 3A3

Dear Mr. Ruck:

RE: Uniroyal Chemical Ltd. NDMA Abatement Plan

Further to your letter of January 24, 1980, please be advised that I have reviewed the abatement plan proposed by the company.

Enclosed is a three page abatement plan, which I believe will satisfy Uniroyal's present obligations under the Emergency Director's Order issued by me on December 30, 1989, under the Ontario Water Resources Act. I, therefore, approve of the implementation of this plan as it is set out. This plan is not an agreement, and in no way alters Uniroyal's obligations under the present Emergency Order of December 30, 1989.

If compliance with the Order is not established, the Ministry will take steps to enforce the Order.

Yours truly,

[signed "S. E. Salbach"]

S.E. Salbach
Director
Ontario Water Resources Act

cc: W. Derry Millar
H. Poch
T.C. Flannery
S. Berger

Enclosure
SES/pd

UNIROYAL CHEMICAL

NDMA ABATEMENT PLAN

1. Uniroyal will not start-up the UBOB process suspected of contributing to the formation of NDMA until it can demonstrate to the Ministry's satisfaction that the process is not a source in the formation of NDMA.
2. Clean-up of waste water collection system up to the aeration tank.
 - All building sumps and drains
 - The Building #8 and general sump
 - Flush all the interconnecting piping
 - Drain and clean both pH basins
 - Drain and clean the clarifier
 - Drain and clean the clarifier water sump

MoE to inspect the clean-up prior to any start-up.

3. Install by-pass around the aeration tank to shorten response time to testing. Completed January 22/90. Uniroyal representatives will review and provide to MoE the impact of by-passing the aeration tank on the removal of contaminants and the effect on the effluent from the Municipal Treatment Plant. If this information is acceptable to MoE, the by-pass can be placed into operation.

4. Start-up the following:

- Flow to Municipal Treatment Plant from equalization tank at a rate of 15M to 25M gallons per day to handle production volume gradually increasing to 50M per day.
- Vitavax production unit
- NaMDT production unit.

5. Take the following split samples:

- Process sumps at respective buildings
- Inlet to pH basin to clarifier
- Outlet of pH basin to clarifier
- Outlet of clarifier
- Outlet of the carbon column
- Outlet of equalization tank
- Outlet of Municipal Treatment Plant

6. Testing:

- Outlet of clarifier 12 to 24 hours after start-up of the process.

Recognizing that NDMA discharges from Uniroyal in the range of 200 PPB coincided with discharges from the Elmira Sewage Treatment Plant above the .5 PPB limit in the December 30 Emergency Order, the following tests will be required:

If less than 10 ppb, no further upstream testing required.

If greater than 10 ppb, test required upstream samples.

- Other testing as required by the December 30, 1989 Director's Order.
- Prior to start-up, Uniroyal will have to submit for MoE approval their analytical procedures and protocol.

7. Successive process start-ups

- Collect two consecutive days of clarifier outlet samples. If the first sample tests less than 10 ppb start up the next process. The procedure in this paragraph will be repeated each time a new process is started up.

8. Sludge removal from equalization tank

It is proposed to empty and remove any sludge that exists in the south equalization tank (balance tank). This tank has a capacity of 200,000 gallons/day to the Municipal Treatment Plant. On completion of this phase, the sludge would be removed from the tank and disposed of at an approved facility. After inspection of the tank, it would be placed back in service. The estimated time required to complete this operation is two weeks.

This operation will remove the main source of sludge from the Uniroyal Waste Water Treatment System.

9. Reporting of sample results

Uniroyal Chemical will provide the Ministry of the Environment (D.Ireland/S.Salbach) with a complete report of analyses for NDMA received to date by January 26, 1990.

Upon receipt of sampling results Uniroyal will immediately provide to MoE. NDMA analytical results.

10. Sampling schedule/grid

Uniroyal Chemical will prepare a table indicating the sampling schedule and frequency as required by MoE and send a copy to the Ministry of the Environment (D. Ireland/S. Salbach) prior to start-up.

11. Calibration of flowmeters

The flowrate of Uniroyal Chemical effluent to the Sewage Treatment Plant must be regulated to ensure consistent levels of treatment prior to discharge to the Canagagigue Creek.

Accordingly, Uniroyal Chemical will calibrate its flowmeter on the line leading to the Sewage Treatment Plant. In addition, the Ministry of the Environment will calibrate the flowmeter at the Sewage Treatment Plant.

The reading of the flowmeter at the Sewage Treatment Plant will be the one used to determine actual flowrates.

12. Aeration tank

The waste water in the aeration tank will be analyzed for NDMA to determine whether this treatment has reduced the NDMA content.

[Notice of 2.2.90]

NOTICE UNDER EMERGENCY ORDER OF DIRECTOR DATED DECEMBER 30, 1989

TO: UNIROYAL CHEMICAL LTD., ELMIRA, ONTARIO

WHEREAS (a) sample(s) have been obtained from the Elmira Municipal Sewage Treatment Plant indicating NDMA in excess of .05 µg/L and in particular: a sample taken January 31, 1990 contained 3.2 µg/L NDMA.

WHEREAS detectable levels of NDMA have been found in Uniroyal sewage, in particular a sample taken January 31, 1990, containing 2300 µg/L NDMA.

PURSUANT TO PARAGRAPH 8 of the Emergency Order dated December 30, 1989, set out below I hereby notify you that you are obliged to immediately discontinue any discharge into the Municipal Sewage Treatment Plant in Elmira.

Failure to do so will be considered by me as an offence under s.66(2) of the Ontario Water Resources Act, R.S.O. 1980, c.361. Notice of such failure will be given to the Investigations and Enforcement Branch of the Ministry of the Environment for prosecution purposes.

SECTION 8 OF THE EMERGENCY ORDER PROVIDES AS FOLLOWS:

Discontinue immediately any discharge into the Municipal Sewage Treatment Plant, in the event that NDMA is detected in the Sewage Treatment Plant effluent at a level greater than .5 µg/L and any detectable quantity of NDMA is present in Uniroyal sewage.

Since the objective of this Emergency Order is ultimately to eliminate all discharges of NDMA, a review of the effluent standard set out in this paragraph will be carried out by the Director and this order would be varied, with notice, accordingly.

Dated February 2, 1990, in Hamilton, Ontario

[signed: 'S. E. Salbach']

S.E. Salbach, Director

Ontario Water Resources

EFFLUENT PARAMETER SCAN LIST

Analytical Test Group

Number	Name	Parameters
1	General Chemistry	Total cyanide Chemical Oxygen Demand (COD) pH Total Kjeldahl Nitrogen (TKN) Ammonia Total Organic Carbon (TOC) Conductivity
2	Phenolics (4AAP)	Phenolics (4AAP)*
3	Sulphide	Sulphide
4	Volatiles, Halogenated	1,1,2,2-Tetrachloroethane 1,1,2-Trichloroethane 1,1-Dichloroethane 1,1-Dichloroethene 1,2-Dichlorobenzene 1,2-Dichloroethane 1,2-Dichloropropane 1,3-Dichlorobenzene 1,4-Dichlorobenzene Bromodichloromethane Bromoform Bromomethane Carbon tetrachloride Chlorobenzene Chloroform Chloromethane Cis-1,3-Dichloropropene Dibromochloromethane Ethylene dibromide Methylene chloride Tetrachloroethene (Perchloroethene) Trans-1-2-Dichloroethene Trans-1-3-Dichloropropene Trichloroethene Trichlorofluoromethane Vinyl chloride (Chloroethene)

Analytical Test Group

Number	Name	Parameters
5	Volatiles, Non-Halogenated	Benzene Ethylbenzene Styrene Toluene o-Xylene M-Xylene and p-Xylene Methylisobutylketone N-methylketone
6	Volatiles, Water Soluble	Acrolein Acrylonitrile
7	Extractables, Base Neutral	Benzothiozole Aniline 4-Bromophenyle phenyl ether 4-Chlorophenyl phenyl ether Bis(2-chloroisopropyl)ether Bis(2-chloroethyl)ether Diphenyl ether 2,4-Dinitrotoluene 2,6-Dinitrotoluene Bis(2-chloroethoxy)methane Diphenylamine 2-Mercaptobenzothiozole N-Nitrosodiphenylamine N-Nitrosodi-n-propylamine N-Nitrosodimethylamine Nitrosodiethylamine Nitrosodibutylamine Nitrosomorpholine Oxathiin Morpholine Diethylamine N-Nitro-N-Phenylurea

Analytical Test Group

Number	Name	Parameters
8	Extractables, Acid(Phenolics)	2,3,4,5-Tetrachlorophenol 2,3,4,6-Tetrachlorophenol 2,3,5,6-Tetrachlorophenol 2,3,4-Trichlorophenol 2,3,5-Trichlorophenol 2,4,5-Trichlorophenol 2,4,6-Trichlorophenol 2,4-Dimethyl phenol 2,4-Dinitrophenol 2,4-Dichlorophenol 2,6-Dichlorophenol 4,6-Dinitro-o-cresol 2-Chlorophenol 4-Chloro-3-methylphenol 4-Nitrophenol m-Cresol o-Cresol p-Cresol Pentachlorophenol Phenol
9	Extractables, Neutral-Chlorinated	1,2,3,4-Tetrachlorobenzene 1,2,3,5-Tetrachlorobenzene 1,2,4,5-Tetrachlorobenzene 1,2,3-Trichlorobenzene 1,2,4-Trichlorobenzene 2,4,5-Trichlorotoluene Hexachlorobenzene Hexachlorobutadiene Hexachlorocyclopentadiene Hexachloroethane Octachlorostyrene Pentachlorobenzene
10	Pesticides	2,4,5-T 2,4-D 2,4-DP 2,4-DB Silvex Lindane Dicamba

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Glossary

10 ⁻⁴	A risk factor of 1 chance in 10,000
10 ⁻⁵	A risk factor of 1 chance in 100,000
10 ⁻⁶	A risk factor of 1 chance in 1,000,000
10 ⁻⁷	A risk factor of 1 chance in 10,000,000
absorption	process involving the taking up of substances by the skin, mucous surfaces or absorbent vessels wherein the substance is transported beyond the surface of the material
adduct	a chemical addition (e.g., an alkyl group) to a macromolecule such as protein or DNA
adenocarcinoma	a carcinoma wherein the cells are arranged in a gland-like form; a malignant adenoma
adenoma	an epithelial tumour with a gland-like structure, which is usually benign
adsorption	process involving the taking up of substances by materials wherein the substance is maintained at the surface of the material
affinity	the degree of binding strength between substances, e.g., an enzyme and its substrate
alkylation	the addition of an alkyl adduct (e.g., methyl, ethyl, propyl) to a larger molecule
Appellant	Uniroyal Chemical Ltd.
APTE	Assuring Protection of Tomorrow's Environment [group of citizens]
background level	the level of an effect or disease which would normally be expected to be present in a specific group or population. Also, the level of a chemical normally found in an environment
BIBRA	British Industrial Biological Research Association

biliary cystadenoma	a cystic adenoma of the bile duct system
bioassay	determination of the activity of a sample of a chemical by noting its effects on a live animal or standard preparation
body-scaling	the adjustment used to translate the dose given to a test animal [eg. a rat] to its equivalent dose given to a human being
carcinogen	a substance which causes the development of malignant tumours (cancers)
carcinogenic	adjective to describe the effect of a carcinogen
carcinogenicity	the ability to produce cancer
carcinoma	a malignant new growth made up of epithelial cells which may spread to other tissues or parts of the body
clastogenic	capable of inducing disruptions or breakages or chromosomes
CofA	Certificate of Approval
CRA	Conestoga-Rovers Associates
de minimis risk	negligible risk (from Latin meaning 'of minimal risk')
dealkylation	the substitution of a hydrogen atom for an alkyl group in an organic compound
denitrosation	the removal of a nitroso group from a nitrosamine or nitrosamide
detoxication	inactivation or removal of toxic chemicals through metabolic reactions
Director	The Director, Hamilton Regional Office, Ministry of the Environment
DMA	dimethylamine
DMNA	An alternative annotation for N-nitrosodimethylamine (NDMA)
DNA	deoxyribose nucleic acid

DNA repair	mechanism of the body to repair damage to DNA [enzymatic processes that take place normally in cells to remove or otherwise repair spontaneous or induced damage to the genetic material]
dose	the quantity of a chemical substance administered
dose-response extrapolation	the process of extrapolating (converting) dose-response information from one exposure level to another (e.g., from high exposure to low exposure)
EAB	The Environmental Appeal Board
endogenous	occurring (produced) within (the body)
EPA	The Environmental Protection Act (R.S.O. 1980, c. 141) as amended
epidemiology	the study of the distribution and dynamics of diseases in human populations including dose-response relationships
exposure	the condition of being in contact with a chemical substance
exposure limit	an acceptable level of exposure to a chemical substance
extrapolation	projection of data, based upon a pattern or trend established by known data, beyond the range of the actual data
foetotoxicity	toxic effects on the fetus
g	gram
gastrointestinal tract	referring to the digestive tract including the stomach and intestine
GC/HRMS	gas chromatography/high resolution mass spectrometry
GC/ITD	gas chromatography/ion trap detector
GC/LMRS	gas chromatography/low resolution mass spectrometry
GC/MS	gas chromatography/mass spectrometry
genotoxic	effects of agents which interact with or directly affect genetic material (i.e., DNA)

Hearing	this hearing by the Environmental Appeal Board
hemangiosarcoma	a tumour of the hemopoietic or vascular system
hepatocarcinoma	a carcinoma of the liver
hepatotoxicity	toxicity that occurs within the liver
HPLC	high performance liquid chromatography
HWC, H&WC	Health and Welfare Canada
hyperplastic nodule	in the liver, an increased number of liver cells in a local area, but with retention of lobular architecture of the liver in the region, that regress following either cessation of chemical treatment or transplantation
in vitro	within test tubes or petri dishes (from Latin meaning 'in glass')
in vivo	within a living body
IRIS	Integrated Risk Information System
kg	kilogram
L	litre
lesion	an injury, structural change or loss of function of a tissue or organ
LMS	Linear Multistage Extrapolation model
Lpcd	litres per capita per day [referring to drinking water consumption]
matrix (or matrix sample)	a sample that contains a mixture of constituents including the substance(s) of interest, as well as other substances
matrix effects	the potential of constituents in a matrix (sample) to interfere with the quantitative analysis of other constituents in the matrix (sample)
MTX	Model free extrapolation method [linear robust extrapolation method]

mg	milligram
mg/L	milligrams per litre (parts per million)
microgram	one millionth of a gram, or 10^{-6} g
milligram	one thousandth of a gram, or 10^{-3} g
MoE	the Ministry of the Environment
Mun.	municipality
nanogram	one billionth of a gram, or 10^{-9} g
NDMA	N-nitrosodimethylamine
ng	nanogram
ng/L	nanograms per litre [parts per trillion]
nitrosamines	family name for various chemical compounds [including NDMA,] formed by the combining of nitrites and amines
nitrosation	a chemical reaction in which amine reacts with an oxide of nitrogen to yield a nitrosamine or a nitrosamide
Notice	a Notice from the Director
OWRA	The Ontario Water Resources Act (R.S.O. 1980, c. 361) as amended
PALIS	Parameters Listing System
pathological endpoint	the most life-threatening result of exposure to a toxin
pg	picogram
picogram	one trillionth of a gram, or 10^{-12} g
ppb	parts per billion (equal to micrograms per litre or kilogram, $\mu\text{g/L}$ or $\mu\text{g/kg}$)
ppm	parts per million (equal to milligrams per litre or kilogram, mg/L or mg/kg)

ppq	parts per quadrillion (equal to picograms per litre or kilogram, or pg/L or pg/kg)
ppt	parts per trillion (equal to nanograms per litre or kilogram, ng/L or ng/kg)
QA	quality assurance
QC	quality control
Reference Dose	(RfD) - the recommended daily human intake of a chemical substance exhibiting a threshold (highly nonlinear) dose-response based upon the NOAEL (no observable adverse effect level) determined from human or animal studies and the use of an appropriate safety factor; RfD values are usually applied to substances that do not produce self-propagated lesions or effects
Region	The Regional Municipality of Waterloo
RfD	reference dose
Risk Specific Dose	(RsD) - the estimated human exposure level to a chemical exhibiting a non-threshold dose-response that is associated with a specified level of risk of developing cancer (e.g., one-in-a hundred propagated lesions or effects (e.g., genotoxic carcinogens)
risk	the probability of an adverse effect from exposure to a chemical that has a hazardous property
RMOS	(Relative Margin of Safety) the ratio of the exposure received by humans to the acceptable exposure limit
RMoW	The Regional Municipality of Waterloo
round-robin	a method of simultaneously comparing, by several different laboratories, the analysis results of the same sample of a chemical compound
RPW	retaining pond west (a Uniroyal waste water retaining pond on the west side of the Canagagigue Creek)
RsD	Risk Specific Dose
slope factor	a linear relationship of risk level to the dose level
STP	the Elmira sewage treatment plant

TEA	Thermal Energy Analyser
teratogenicity	the ability to produce congenital malformations (birth defects)
threshold dose	the level which must be reached before effects are observed
toxicant	a toxic agent
Twp, TWP	The Township of Woolwich
U.S. EPA	The United States Environmental Protection Agency
VSD	Virtually Safe Dose - same as RsD.
WPCP	Water Pollution Control Plant
µg	microgram
µg/L	micrograms per litre (parts per billion)

CA20NEB 92155

Ontario. Environmental Appeal Board.

IN THE MATTER OF THE ONTARIO WATER RESOURCE
(R.S.O. 1980, C.361) AS AMENDED, AND IN THE
APPLICATIONS BY UNIROYAL CHEMICAL LTD.... 1

**RESOURCE CENTRE
INST. FOR ENVIRON'L. STUDIES
UNIVERSITY OF TORONTO**



